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PART I. VOL. XXVII.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

SESSION 1900-1901.

SOLD AT THE ROOMS OF THE SOCIETY,
QUEEN'S CHAMBERS, 5, JOHN DALTON STREET, MANCHESTER.

MDCCCCI.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME TWENTY-SEVENTH.

PARTS I.—XVII.

FOR SESSIONS 1900-1901, AND 1901-1902.

MANCHESTER:
SOLD AT THE ROOMS OF THE SOCIETY,
5, JOHN DALTON STREET, MANCHESTER.
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UNIV. OF CALIFORNIA

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XXVII. SESSION 1900-1901.

The ANNUAL MEETING of the Members was held on Tuesday, October 9th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. JOSEPH DICKINSON (in the absence of the President) in the Chair.

NEW MEMBER.

Mr. WILLIAM MCKAY, New Moss Colliery, Audenshaw, was balloted for, and unanimously elected a member of the Society.

THE ANNUAL REPORT OF THE COUNCIL AND TREASURER'S STATEMENT.

Mr. W. SAINT, one of the Honorary Secretaries, read the Report of the Council, for the Session 1899-1900, as follows:—

REPORT OF THE COUNCIL,

For the Session 1899-1900.

In presenting their Sixty-second Annual Report, the Council have to congratulate the members on the satisfactory position in which the Society has been maintained both as regards their numbers and the various subjects brought forward for discussion, which have been published in the Society's Transactions during the past Session.

The usual number of Ordinary Meetings were held, namely, six in the Society's Rooms, 5, John Dalton Street, and two in the Mining School, Wigan. An extra Meeting was held at the Owens College on the 10th of November, under the Presidency of Professor W. Boyd Dawkins, when Professor Edward Hull, F.R.S., &c., gave an address "On Sub-oceanic Terraces and River Valleys off the Coasts of the British Isles and Western Europe."

Seven new members have been elected.

The losses include one honorary member, Mr. George H. Morton, F.G.S., and two ordinary members by death; and four by resignations.

The Society now consists of:—

Honorary Members	10
Life Members..	10
Ordinary Members	213
Total	233

Communications on geological subjects have also been read by Mr. George Wild, Mr. J. Lomax, Messrs. Barnes

and Holroyd, Mr. Mark Stirrup, Mr. C. E. De Rance, Mr. George Caldwell, and Professor Edward Hull.

Papers and short communications, some of considerable importance appertaining to mining, have been received from the President, Mr. W. S. Barrett, in which amongst others, he discussed the question of the duration of our coal supply; Mr. Joseph Dickinson, Mr. J. G. Patterson, Mr. Thomas Bell, Mr. Joseph Crankshaw, Mr. James Keen, Mr. George Peace, and Mr. George B. Harrison.

A complete list of the papers and short communications read during the Session is appended.

The Society's connection with the British Association for the Advancement of Science, as a corresponding Society, is maintained, and at the recent meeting held in Bradford, the Society was represented by Mr. William Watts, F.G.S., who, at the request of the Council, undertook to act as our delegate.

The usual technical journals, and the publications of the various Societies with whom we exchange transactions continue to be received, and these, together with the valuable library and geological maps on the one inch and six inch scales are available for reference by the members on week-days between the hours of 9-30 a.m. and 5-30 p.m., except on Saturdays when the Rooms are closed at 1 p.m. It is desired that these facilities for references may be more generally made use of by a larger body of members. All are cordially invited to introduce their friends to the meetings, and thus in some degree assist in making its valuable work more generally known.

The Treasurer's Statement of Accounts hereto appended shows the financial position of the Society to be satisfactory.

The Council are pleased to report that the Society's securities held by the late Trustee (Mr. Clegg Livesey) have been transferred to the present Trustees of the Society, Mr. Joseph Dickinson and Mr. Lees Knowles, and have been deposited by them in the St. Ann Street branch of the Williams Deacon and Manchester and Salford Bank, Limited.

In conclusion, the Council earnestly desire to impress the general body of members with the importance of more regular attendance at the monthly meetings, and of contributing papers for discussion in aid of the objects of the Society, namely, the collection and diffusion of knowledge respecting geology and mining.

FINANCE.

Mr. SAINT also read the following abstract of the Treasurer's accounts, which were approved :—

MANCHESTER GEOLOGICAL SOCIETY.—ABSTRACT OF ACCOUNTS FOR THE YEAR 1899-1900.

Dr. *Cr.*

1899.	Receipts.	£	s.	d.	£	s.	d.
Oct. 5.	To Balance in Bank				38	7	4
1900.							
Sept. 29.	,, Members' Subscriptions:—						
	Current	164	10	0			
	Arrears	19	0	0			
					183	10	0
	To Dividends:—						
	Birkenhead Railway	23	2	0			
	Lancashire & Yorkshire Railway.	21	3	4			
					44	5	4
	,, Bank Interest				0	14	4
	,, Hire of Rooms				2	10	0
	,, Special Contribution, Mr. J. Gerrard				4	7	6
	,, Transactions sold				3	14	4
	,, Sundry Receipts				1	5	7½
					£278	14	5½

1900.	Payments.	£	s.	d.
Oct. 6.	By Rent and Expenses of Rooms	90	19	11½
	,, Printing Transactions	116	6	6
	,, Circulars and Stationery	11	11	4
	,, Postages, &c.	16	15	4
	,, Reporters	10	10	0
	,, Library	7	7	3
	,, Fire Insurance	0	12	6
	,, Law Charges, &c.	5	1	8
	,, Collector's Commission	9	3	6
	,, Sundries	0	5	4
	,, Balance in Bank	10	1	1
		£278	14	5½

BALANCE SHEET, 30th September, 1900.

Dr. *Cr.*

Liabilities.	£	s.	d.
To Outstanding Accouts:—Electric Light	0	8	4
J. Roberts & Sons	50	7	6
J. E. Cornish	0	4	6
	£51	0	4
,, Balance	2051	0	9
	£2102	1	1

Assets.	£	s.	d.
By £600 Birkenhead Railway Consolidated Preference Stock Guaranteed (at £134)	804	0	0
,, £733 Lancashire & Yorkshire Railway 3% Consolidated Preference Stock (at £100)	733	0	0
,, Library and Furniture, say	500	0	0
,, Cash in Bank	10	1	1
,, Arrears of Subscription, £110, say	55	0	0
	£2102	1	1

The Investments consist of £600 Birkenhead Railway Consolidated Stock (Guaranteed), and £733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock. The Certificates for these are deposited at the Williams Deacon and Manchester and Salford Bank, St. Ann's Street Branch, and were inspected by us on October 3rd, 1900.

Audited and found correct, October 8th, 1900,

JON. BARNES,
GEO. H. WINSTANLEY, } Auditors.

GEORGE H. HOLLINGWORTH, Treasurer.
8th October, 1900.

ELECTION OF OFFICERS.

The CHAIRMAN said: The next duty was to elect the Officers and Council for the ensuing year. The matter of selection had been under the consideration of the Council at two Meetings, and they unanimously recommended that one of the old members of the Society, and an important colliery manager, Mr. G. C. Greenwell, Junr., be the President for the ensuing year.

Mr. SAINT moved, and Professor BOYD DAWKINS seconded, that Mr. G. C. Greenwell, Junr., M.Inst.C.E., F.G.S., be the President of the Society for the next year.

The proposal was unanimously approved.

On the motion of Professor BOYD DAWKINS, seconded by Mr. J. TONGE, the following were elected Vice-Presidents:—Mr. W. F. Holroyd, F.G.S.; Mr. C. R. Lindsey, B.Sc.; Mr. George Peace; and Mr. Lionel B. Wells, C.E.

Mr. DURY MITTON moved, Mr. J. BARNES seconded, and the meeting unanimously agreed, that Mr. George H. Hollingworth, F.G.S., &c., be Honorary Treasurer.

Mr. William Saint, and Mr. J. Tonge, Junr., were reappointed Honorary Secretaries, the resolution being moved by Mr. MARK STIRRUP, and seconded by Prof. BOYD DAWKINS.

The following gentlemen were appointed members of the Council, in addition to the above-named Officers, namely:—Messrs. J. Barnes, Joseph Crankshaw, H. H. Bolton, Junr., D. H. F. Mathews, S. S. Platt, J. Rigby, Frederick J. Grant, John Gerrard, George B. Harrison, A. Dury Mitton, George Caldwell, and W. N. Atkinson.

The Past Presidents continue under the rules *ex officio* members of the Council.

Mr. W. F. Holroyd, F.G.S., was appointed Honorary Librarian in succession to Mr. Mark Stirrup. Messrs. J. Barnes, F.G.S., and G. H. Winstanley, F.G.S., were appointed Honorary Auditors.

"GOLDEN VICTORIA."

This was the title of an address which was then delivered by Mr. JAMES STIRLING, Mining Representative for Victoria. With the aid of a large number of excellent lantern slides Mr. Stirling gave a vivid picture of Victoria, its rivers, lakes, and landscapes, and the story of its gold and coal deposits. He also sketched what may be termed the geological history of the Colony. Speaking of the enormous deposits of Brown coal,—276 feet in thickness, the thickest known—the lecturer said an attempt was about to be made to utilise this coal in the generation of electrical energy. Concerning gold mining he spoke in hopeful terms. There was, he said, still plenty of gold, enough to keep the gold mining industry going for very many years—for centuries, in fact. Gold mining in Victoria was still in its infancy, and the gold already won since 1851, 64,452,384 ozs. of gold, or in other words £257,809,528 of gold was obtained from a small area of the known gold-producing rocks—which covered over two-thirds of the Colony.

At the close of the address the CHAIRMAN expressed the pleasure which all present had experienced in listening to what he termed the happy description which Mr. Stirling had given of Victoria, and in looking upon the beautiful illustrations. He asked Professor Boyd Dawkins to move a vote of thanks to Mr. Stirling for his interesting address.

Professor BOYD DAWKINS said the task of moving a vote of thanks to Mr. Stirling was an extremely easy and agreeable one for him to do. The thanks of the audience had indeed been already conveyed in the close attention to the lecture and the applause which followed its delivery. He was loth to interpose any words of his own between the address and those remarks which he expected the Chairman

was about to offer, and which would come with so much more effect from a gentleman of Mr. Dickinson's experience. He would therefore content himself with simply proposing a vote of thanks to Mr. Stirling, adding that he had listened with the liveliest interest to the lecture, and had learned not merely a great deal about the geology of that interesting part of the world which he had the opportunity of visiting and wandering over, alas! many years ago, but a great deal of its hills and forests and beauty for which he was not prepared.

Mr. MARK STIRRUP, in seconding the proposal, said he was sure there was only one opinion amongst them, and that was that they had had a most interesting discourse concerning one of our self-governing colonies, with which we had been, perhaps, brought by recent events into somewhat closer connection. They had had an address which dealt not merely with the geology of the country, but which had traversed the whole range of its natural history. Mr. Stirling had shown them, not only the mining operations, but the irregular methods, and the means taken to get at the precious metals. The views, in many cases, were exceptionally beautiful. Perhaps in the past, too much had been said of the dryness of Australia, from the fact of the drought stricken districts being taken as representative of the whole, as in the case of the thousands of sheep dying for want of water; so that when they had these views put before them in so pleasant a way they seemed to tell one that all parts of the Australian continent were not so devoid of water as had been supposed by many people. He had been exceedingly well pleased, and had learned something more of the geology of Australia, and the wonderful character of the country, than he had previously known, and had very great pleasure in seconding the vote of thanks.

The CHAIRMAN, in submitting the motion—which was adopted with acclamation—said, that as he saw a great

number of mining friends present, he would like on their behalf, and on his own account, to allude to the views which showed the veins in the rocks and the direction in which they ran. He desired to know what was the course, and whether there were any cross veins intersecting the veins running apparently chiefly north and south, and if there were, which bore the most minerals.

Mr. STIRLING, after acknowleding the vote of thanks, gave some further details of the quartz veins found in Australia. They had, he said, all classes of veins. The Bendigo district was one in which the veins were very large.

In answer to Mr. Gerrard, Mr. Stirling said he had ascertained, by his own tests, that in mines 3,500 feet deep, the temperature of the rock was about 93° Fahrenheit; at a depth of 3,300 feet the temperature of the air was as high as 105° at certain times. As regarded the rule of increase in the mean temperature of the rocks, his investigation showed, about 1° Fahrenheit for every 125 feet below the line of no variation, which was about 80 feet from the surface.

Mr. HENRY HALL said he thought there was something wrong with the underground temperature, for in this country they found the temperature rose about 1° in 60 feet, beginning with, say, 50° at 50 or 60 feet below the surface.

Mr. STIRLING said his figures were the result of his own investigations with the best instruments.

Professor BOYD DAWKINS said the observations of the lecturer fully accorded with observations taken in deep sinkings on the Continent.

LIST OF PAPERS AND SHORT COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE SOCIETY DURING THE SESSION 1899-1900.

1899.

November. Hull, Prof. Edward, M.A., LL.D., F.R.S., F.G.S. "On Sub-Oceanic Terraces and River Valleys off the Coasts of the British Isles and Western Europe."

Dickinson, Joseph, F.G.S. "On Pit Props and their setting."

December. Patterson, J. G. "On Howatt's latest Safety Lamp."

Bell, Thomas, M.E. "Notes on the working of Coal Mines under sea, and under the Permian Feeder of Water in the County Durham."

Stirrup, Mark, F.G.S. "Report of the Delegate to the Meeting of the British Association, at Dover, September, 1899."

1900.

January. Crankshaw, Joseph, F.G.S. "Coal Mining in South Russia."

Keen, James. Further Notes "On the Sinking of two shafts at Maypole Colliery, Abram, near Wigan."

Patterson, J. G. "Howatt's latest Safety Lamp with Patterson's Gauzes."

February. Wild, George. "On New and Interesting Features in Trigonocarpon Olivæforme."

Lomax, J. "A New Specimen of Calamites with Roots."

Peace, George. "On the Sinking of No. 3 Nook Pit by the Astley and Tyldesley Coal and Salt Co., Ltd."

March. Barnes, J., F.G.S., and Holroyd, W. F., F.G.S. "Some further Notes on the Sea Beach in the Carboniferous Limestone, Derbyshire."

April. Stirrup, Mark, F.G.S. "On the Minerals Celestine and Baryto-Celestine."

Dickinson, Joseph, F.G.S. "Brief Notes on the late Mr. John Nixon, and Sir George Elliott, Bart."

De Rance, C. E., F.G.S. "The Salford Earthquake."

Hull, Prof. Edward, F.R.S. "On the Sub-Oceanic Valley of the River Congo."

Harrison, George B. "Acetyline Lamp for Miners' use."

May. Sutcliffe, Richard. "On a New Method of Sinking Pits by Machinery."

Ashworth, James, M.E. "Failures of Safety Lamps whilst in use, and some of the Disasters caused thereby."

June. Bell, Thomas. Further Notes "On the Working of Coal Mines under the Sea; also under the Permian Feeder of Water in the County of Durham."

Barnes, J., F.G.S., and Holroyd, W. F., F.G.S. "On the Mottled Carboniferous Limestone of Derbyshire."

Smith, Sebastian. "Safety Props for supporting Cages in the Headgear in cases of Overwinding."

Harris, George E. "On the Makum Coalfield, Assam."

Caldwell, George. "On White Sandstone Nodules found in No. 1 Pit, Lord Derby's Siding, Rainford."

NEW ORDINARY MEMBERS.

Bennett, Samuel B.
Deane, Adam.
Jobson, Henry.
Leah, Richard.
Ollerenshaw, W.
Rhodes, John R.
Tatham, Roger.

HONORARY MEMBER DECEASED.

Morton, George H.

MEMBERS DECEASED.

Brocklehurst, Thomas.
Hampson, Joshua.

MEMBERS RESIGNED.

Bramall, Ernest E.
Hallas, George H.
Pearce, Charles H.
Stafford, Thomas.

The following is the complete list of the Council for the ensuing year:—

President:

G. C. GREENWELL, JUNR., M.INST.C.E., F.G.S.

Vice-Presidents:

GEORGE PEACE. | C. R. LINDSEY, B.Sc.
W. F. HOLROYD, F.G.S. | LIONEL B. WELLS, M.INST.C.E.

Ex-Officio Vice-Presidents:

R. CLIFFORD SMITH, F.G.S.
THE RIGHT HON. THE EARL OF CRAWFORD & BALCARRES.
SIR U. J. KAY-SHUTTLEWORTH, BART., M.P.
G. C. GREENWELL, F.G.S. | EDWARD PILKINGTON, J.P.
PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
HENRY HALL, H.M.I.M. | JOHN S. BURROWS, F.G.S.
JAMES TONGE, F.G.S., ASSOC.M.INST.C.E.
W. SAINT, H.M.I.M. | MARK STIRRUP, F.G.S.
ROBERT WINSTANLEY, C.E. | JOHN RIDYARD, F.G.S.
W. WATTS, F.G.S. | W. S. BARRETT, J.P.

Hon Treasurer:

G. H. HOLLINGWORTH, F.G.S.

Hon, Secretaries:

WILLIAM SAINT, H.M.I.M. | JAMES TONGE, JUN., F.G.S.

Other Members of the Council:

W. N. ATKINSON, H.M.I.M. | FREDK. J. GRANT.
J. BARNES, F.G.S. | GEO. B. HARRISON, H.M.I.M.
H. H. BOLTON, JUN. | D. H. F. MATTHEWS, H.M.I.M.
GEO. CALDWELL. | A. DURY MITTON.
JOSEPH CRANKSHAW, F.G.S. | S. S. PLATT, M.INST.C.E., F.G.S.
JOHN GERRARD, H.M.I.M. | JOHN RIGBY.

Hon. Librarian:

W. F. HOLROYD, F.G.S.

Hon. Auditors:

J. BARNES, F.G.S. | GEO. H. WINSTANLEY, F.G.S.

Trustees:

JOS. DICKINSON, F.G.S. | LEES KNOWLES, M.A., LL.M., M.P.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-39-40	Egerton, The Rt. Hon. Francis, M.P.
1141-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-46-47	Moseley, Sir Oswald, Bart.
1747-48-49	Thicknesse, Ralph, M.P., Wigan.
1851-52-53	Black, James, M.D., F.G.S.
1853-54-55	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-61	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst.C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John. M.Inst.C.E., J.P.
1873-74	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Prof. W. Boyd, M.A., F.R.S., F.G.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P.
1881-82	Gilroy, George, M.Inst.C.E.
1883-84	Pilkington, Edward, J.P.
1885-86	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.
1897-98	Ridyard, John, F.G.S.
1898-99	Livesey, Clegg, J.P.
1899-1900	Barrett, W. S., J.P.

APPENDIX TO THE REPORT.

ADDITIONS TO THE LIBRARY, 1899-1900,

To September 30th, 1900.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1898-99. *From the Society.*

Birmingham.—South Staffordshire and East Worcestershire Institute of Mining Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Bradford.—Annual Report (29th) of Libraries and Art Museum Committee.

Bristol.—Naturalists' Society. Proceedings. New Series, Part 1, Vol. IX.

Bristol.—Museum. Report for 1899. *From H. Bolton.*

Cambridge.—Museum. 34th Annual Report Museums and Lecture Rooms' Syndicate for 1899; also Annual Report of the Library, 1899. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Report and Transactions for 1898-9. Vol. XXXI. *From the Society.*

Cardiff.—South Wales Institute of Engineers. Proceedings. Nos. 1, 6, 7, 8, Vol. XXI. No. 1, Vol. XXII. *From the Institute.*

Chester.—29th Annual Report of Chester Society of Natural Science and Literature for 1899-1900. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Dublin.—Royal Society. Transactions. Nos. 2, 3, 4, 5, 6, 7, Vol. VII. Proceedings. Part 1, 2, Vol. IX. Economic Proceedings. Nos. 1, 2, Vol. I.

Essex.—The Essex Naturalist. Parts 4-12, Vol. XI. *From the Essex Field Club.*

Edinburgh.—Royal Society. Proceedings Vol. XXXII.

Edinburgh.—Royal Geological Society. Transactions. Part 4, Vol. VII. *From the Society.*

Edinburgh.—Royal Physical Society. Proceedings. Part 2, Vol. XIV. *From the Society.*

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Leicester.—Literary and Philosophical Society. Transactions. Parts 5, 6, 7, 8, Vol. V., New Series. *From the Society.*

Liverpool.—Geological Society. Proceedings. Part 3, Vol. VIII.

Liverpool.—Public Libraries and Art Galleries. 47th Annual Report, 1899.

London.—British Association for the Advancement of Science. Reports for 1899. *From the Association.*

London.—British Museum. List of Genera and Species of Blastordea in the British Museum. Catalogue of Cretaceous Bryozoa.

London.—Geological Magazine. (New Series.) Decade IV. Nos. 10, 11, and 12, Vol. VI. Nos. 1-9, Vol. VII. *Purchased.*

London.—Geological Society. Quarterly Journal. No. 220, Vol. LV. Nos. 221, 222, 223, Vol. LVI. *From the Society.*

London.—Geologists' Association. Proceedings. Parts 5, 6, 7, 8, Vol. XVI. *From the Association.*

London.—Institution of Mechanical Engineers. Proceedings. Nos. 2 and 3, 1899. *From the Institution.*

London.—Iron and Coal Trades' Review. Nos. 1649 to 1661, Vol. LIX, Nos. 1662 to 1687, Vol. LX. Nos. 1688 to 1700, Vol. LXI.

London.—Iron and Steel Institute. Journal. Vols. LVI. and LVII. *From the Institute.*

London.—Palaeontographical Society. Vol. LIII., for 1899. *Purchased.*

London.—Royal Society. Proceedings. Nos. 419 to 423, Vol. LXV. Nos. 424 to 434, Vol. LXVI., and the Reports of the Malaria Committee for 1899 and 1900. *From the Society.*

London.—The Colliery Guardian. Nos. 2023 to 2035, Vol. LXXVIII. Nos. 2036 to 2061, Vol. LXXIX. Nos. 2062 to 2074, Vol. LXXX.

London.—The Mining Journal. Nos. 3345 to 3358, Vol. LXIX. Nos. 3359 to 3396, Vol. LXX.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Part 5, Vol. XLIII. Parts 1, 2, 3, 4, Vol. XLIV. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 9 to 12, Vol. XI. Nos. 1-12, Vol. XV. Nos. 1-3, Vol. XVI. *From the Society.*

Manchester.—The Owens College Museum. Report for the year 1899 and 1900. Publications. Nos. 30, 31. *From the College.*

Newcastle-upon-Tyne.—Institution of Mining Engineers. Transactions. Nos. 4, 5, 6, Vol. XVII. Nos. 1, 2, 3, 4, 5, Vol. XVIII.

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Institution of Mining Engineers; also Annual Report 1898-9. *From the Institution.*

Penzance.—Geographical Society of Cornwall. Transactions. Part 5, Vol. XII.

Southampton.—Hampshire Field Club. Proceedings. No. 1, Vol. IV.

Stafford.—North Staffordshire Field Club. Annual Report and Transactions for 1899 and 1900. *From the Club.*

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Wigan.—Science and Art of Mining. Nos. 4 to 26, Vol. X. Nos. 1 to 3, Vol. XI.

BOOKS, PAMPHLETS AND REPORTS.—ENGLISH AND FOREIGN.

Mineral Statistics of the Mines and Quarries. Parts 3 and 4, for 1898; Part 1, 1899; also H.M. Inspector's Report of Mines and Quarries for the S.W. District for 1899. London. *Presented by Joseph S. Martin.*

Mines and Quarries, Report for 1899 for the North Staffordshire District, by W. N. Atkinson. *Presented by the Author.*

Description of a Geological Map of Liverpool, by G. H. Morton, F.G.S. *Presented by the Author.*

Year Book of Scientific and Learned Societies for 1900. *Purchased.*

The Gypsum Boulder of Great Crosby, by T. M. Reade. *Presented by the Author.*

Guide to Queensland.

Catalogue of Scientific Literature, Queensland. Volume with maps of goldfields.

Queensland Government Mining Journal. *Presented by the Agent-General for Queensland.*

Notes on the Minerals of Japan, by Kotora Jimbō.

Notes on the Geology of the Dependent Isles of Taiwan, by B. Kotô.

Report on the Observations of Underground Temperature at Bendigo, by Mr. James Stirling.

Report on the Victorian Goldfields, Nos. 3 and 7, by Mr. James Stirling.

Petrography of the Rocks of South Gippsland, by Mr. James Stirling.

Victoria and its Mines and Minerals. *Presented by Mr. James Stirling.*

La Speleologie, by A. E. Martel.

Les Iguanodous de Bermissart, by E. Vanden Brock. *Presented by the Author.*

INDIA.

Calcutta.—Memoirs of the Geological Survey of India. Vol. XXIX. and No. 1, Vol. XXX.

Calcutta.—General Report of the Geological Survey of India. 1899 and 1900. *From the Governor General in Council.*

Australia.

Adelaide.—Royal Society of South Australia. Transactions. Part 1 and 2, Vol. XXIII. Part 1, Vol. XXIV. Memoirs, Nos. 1 and 2, Vol. I. *From the Society.*

Melbourne.—The Australian Mining Standard. Nos. 563-4, 566, Vol. XVI.; Nos. 583, 585 to 609, Vol. XVII.; Nos. 610 to 614, Vol. XVIII. *From the Editor.*

Sydney.—Geological Survey of New South Wales: Department of Mines. Records. Part 3, Vol. VI. Mineral Resources. Nos. 6 and 7, and Annual Report for 1898. *From the Hon. the Minister of Mines.*

Sydney.—Royal Society of New South Wales. Journal and Proceedings. Vol. XXXII., and Vol. XXXIII.

Canada.

Halifax, N.S.—Nova Scotian Institute of Science. Proceedings and Transactions. Part 1, Vol. X., 2nd Series. *From the Institute.*

Hamilton.—Hamilton Association. Journal and Proceedings for 1898-9. No. 15. *From the Association.*

Ottawa.—Canadian Mining Institute. Journal. Vol. III.

Ottawa.—Canadian Mining Review. Nos. 9, 10, 11, 12, Vol. XVII.; Nos. 2, 3, 4, 5, 6, Vol. XIX. *From the Editor.*

Ottawa.—Geological Survey of Canada. Annual Report for 1897. *From the Director of the Survey.*

St. John, New Brunswick.—Natural History of New Brunswick. Bulletin 18. Part 3, Vol. IV. *From the Society.*

Toronto.—Canadian Institute. Proceedings. Part 6, Vol. I (New Series); Parts 8 and 9, Vol. II. and Vol. VI. *From the Institute.*

Toronto.—Bureau of Mines. Reports. Vol. III., V., VI., VII.. and Parts 1 and 2, Vol. VIII.

U.S. America.

Baltimore.—Maryland Geological Survey. Vol. III. *From the State Geologist.*

Baltimore.—Maryland Weather Service. Vol. I.

Buffalo.—Buffalo Society of Natural Sciences. Bulletins. Nos. 2 and 4, Vol. VI.

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. No. 10, Vol. XXXII.; Vol. XXXIV.; and Nos. 3, 4, 5, 6, 7, 8, Vol. XXXV.; Vol. XXXVI., No. 1; Vol. XXXVII., Nos. 1 and 2. Annual Report of the Museum of Comparative Zoology for 1898-9. *From Alex. Agassiz.*

Chapel Hill, N. Carolina.—The Elisha Mitchell Scientific Society. Journal. Parts 1 and 2, Vol. VI. 1899.

Chicago.—Field Columbian Museum. Annual Report for 1898-9. Geological Series. No. 7, Vol. I. Zoological Series. Nos. 16 and 17, Vol. I. *From the Museum.*

Chicago.—Academy of Sciences. Bulletin. No. 3.

Denver.—Colorado Scientific Society. Proceedings for 1899-1900. *From the Society.*

Indianopolis.—Mineral Resources. 23rd Report (1898).

Iowa.—Geological Survey of. Vol. IX. *From the Director of the Survey.*

Madison.—Wisconsin Academy of Science Arts and Letters Transactions. Part 1, Vol. XII.

Minneapolis.—The American Geologist. Nos. 4, 5, 6, Vol. XXIV.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXV.; and Nos. 1, 2, Vol. XXVI. *Purchased.*

Minneapolis.—Geological and Natural History Survey of Minnesota. 24th Annual Report, for 1895-98.

New York.—The American Museum of Natural History. Bulletin. No. 2, Vol. XI.; Vol. XII.; also Annual Report for 1899. *From the Museum.*

New York.—American Institution of Mining Engineers. Transactions. Vol. XXVIII., 1899.

New York.—Stone. Nos. 4, 5, 6, Vol. XIX.; Nos. 1, 2, 3, 4, 5, 6, Vol. XX.; Nos. 1, 2, Vol. XXI. *Presented by the Publisher.*

Philadelphia.—Franklin Institute. Journal. Nos. 4, 5, 6, Vol. CXLVIII.; Nos. 1, 2, 3, 4, 5, 6, Vol. CXLIX.; Nos. 1, 2, 3, Vol. CL. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2, 3, 1899; Part 1, 1900. *From the Academy.*

Philadelphia.—American Philosophical Society. Proceedings. No. 160, Vol. XXXVIII.

Scranton, Pa.—"Mines and Minerals." Nos. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. XX.; Nos. 1, 2, Vol. XXI. *From the Editor.*

Washington.—Smithsonian Institute. Report of the U.S. State Museum, 1897.

Washington, U.S.—Geological Survey. Monographs XXXIII., XXXIV., XXXVI., XXXVII., and XXXVIII. 19th Annual Report. Parts 2, 3, 5, and 5 continued. 20th Annual Report. Parts 1, 6, and 6 continued. Atlas to accompany Monograph XXXI. Bulletins 150 to 162.

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 3, 4, 5, 6, Vol. XXXIV.; Nos. 1, 2, Vol. XXXV. Verhandlungen, Parts 7, 8, 9, 10, Vol. XXVI.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXVII. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft, Nos. 2, 3, 4, Vol. LI.; No. 1, Vol. LII. *From the Society.*

Brussels.—Société Royale Malacologique de Belgique. Annales Vol. XXXI. and Vol. XXXII. *From the Society.*

Caen.—Société Linnéenne de Normandie (5th Series), Vol. II. *From the Society.*

Christiania.—Archiv. Mathematik og Naturvideushab. Parts 3, 4, Vol. XX.; Parts 1, 2, 3, Vol. XXI.

Dresden.—"8 Isis," July—December, 1898, January—December, 1899. *Presented by Naturwissenschaftliche Gesellschaft Isis.*

Freiburg.—Naturforschenden Gesellschaft, Berichte. No. 2, Vol. XI.

Helsingfors.—Commission Géologique de la Finlande. Parts 8, 9, 10, 11, Vol. I. Explanatory Notes with Map No. 34. *From the Director.*

Iglo.—Jahrbuch des Ungarischen Karpathen-Vereines. No. XXVII.

Kazan (Russia)—La Société des Naturalistes de l'Université. Nos. 4-6, Vol. XXXII.; Nos. 4-6, Vol. XXXIII.

Keiff (Russia.)—La Société des Naturalistes Memoirs. No. 1, Vol. XVI.

Lausanne.—Société Vaudoise. Bulletins Nos. 132-134, Vol. XXXIV.; Nos. 134, 135, 136, Vol. XXXVI.

Lille.—Société Géologique du Nord. Annales, Vol. XXVII., 1898.

Mexico.—Sociedad Científica "Antonio Alzate." Memorias Y. Revista. Nos. 9, 10, 11, 12, Vol. XII. Nos. 1, 2, 3, 4, 5, 6, Vol. XIV.

Mexico.—Institute Geologies de Mexico Boletins. Nos. 12, 13.

Madrid.—Boletin del Ayuntamients de Madrid. No. 97, Vol. II.

Montevideo.—Annales del Museo Nacional. Nos. 12, 13, Vol. III.

Naples.—Rendiconti dell' Accademia della Scienze Fisiche e Mathematiche. Parts 8, 9, 10, 11, 12, Vol. V.; Parts 1, 2, 3, 4, 5, 6, 7, Vol. VI. *From the Academy.*

Paris.—Société de Spéléogique. "Spelunca." No. 16, Vol. IV.; Nos. 17, 18, 19, 20, Vol. V. *From the Society.*

Paris.—Sociéte Géologique de France. Bulletin. No. 6, Vol. XXVI.; Nos. 1-4, Vol. XXVII.

Rome.—Atti della Reale Accademia dei Lincei. Rendiconti. Nos. 6, 7, 8, 9, 10, 11, 12, 2nd Series, Vol. VIII.; Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. IX.; Nos. 1, 2, 3, 4, 5, 2nd Series, Vol. IX. *From the Academy.*

St. Petersburg.—Comité Geologique. Bulletin. Nos. 3-10, Vol. XVIII. Memoirs. No. 4, Vol. VII.; No. 5, Vol. IX.; No. 3, Vol. XV. *From the Society.*

St. Petersburg.—Russ. Kaiser Mineralog. Gesellschaft. Verhandlungen. No. 2, Vol. XXXVI. Materials for Russian Geology. Vol. XIX.

St. Petersburg.—L'Académie Impériale des Sciences. Bulletin. No. 5, Vol. VIII.; Nos. 1, 2, 3, 4, 5, Vol. IX.; Nos. 1, 2, 3, 4, 5, Vol. X.; Nos. 1, 2, 3, 4, 5, Vol. XI.; No. 1, Vol. XII. *From the Academy.*

Stockholm.—Académie Royale Suédoise des Sciences. Bulletin. No. 24. Memoirs 29 and 30.

Upsala.—Geological Institution of Upsala. Bulletin. No. 8, Vol. IV.

SOCIETIES WITH WHICH THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHICH A COPY IS SENT FREE.

I—ENGLAND.

London .....British Association for the Advancement of Science, Burlington House, London.
British Museum, The Superintendent, Copyright Office.
British Museum Library, Natural History Department, Cromwell Road, Kensington.
Geological Society, Burlington House, W.
Geological Survey, Jermyn Street, S.W.
Geologists' Association, University College, Gower Street, W.C.
Institution of Mechanical Engineers, Storey's Gate, St. James' Park, Westminster, S.W.
Iron and Steel Institute, 28, Victoria Street, S.W.
Royal Institution of Great Britain, Albemarle Street
Royal Society, Burlington House, W.
Public Library, Kensington, High Street, W.

Manchester .....The Manchester Association of Engineers, Grand Hotel, Aytoun Street.
Field Naturalists' Society.
Free Library, King Street.
Literary and Philosophical Society, 36, George Street.
Manchester Geographical Society, 16, St. Marys' Parsonage.
The Owens College.
Salford Royal Museum and Library

Barnsley.....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3 Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Clifton.

Cambridge .....Geological Museum, University.
University Library.

Cardiff .....Cardiff Naturalists' Society, 44, Loudoun Square.
South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester .....Society of Natural Science, Grosvenor Museum.

Chesterfield.....Chesterfield and Midland Counties Institution of Engineers (G. A. Lewis, Secretary, Albert Street, Derby).

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.
Mining Association and Institute of Cornwall, Tuckingmill, Camborne.

Essex .....Essex Field Club, Passmore-Edwards Museum, Romford Road, Stratford, Essex.

Exeter .....Albert Memorial Museum.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, 259, Hyde Park Road, Leeds).
Geological Association, Mechanics' Institution, Cookridge Street.

Leicester.....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Association, Free Library, William Brown Street.
Geological Society, Royal Institution.
Science Students' Association, Royal Institution, Colquitt Street.

Mirfield .....Yorkshire Geological and Polytechnic Society, Hopton, Mirfield.

Newcastle-on-Tyne Institution of Mining Engineers.
North of England Institute of Mining and Mechanical Engineers.

Newcastle-under-Lyme ..... North Staffordshire Naturalists' Field Club, (W. Wells Bladen, Esq., Stone, Staffordshire).

Norwich .....Norfolk and Norwich Naturalists' Society.

Oxford .....Bodleian Library.
Radcliffe Library.

North Shields....Public Free Library.

Rochdale.....Literary and Scientific Society, 135, Freehold Street.

Southampton ....Hampshire Field Club, Harley Institution.

Stoke-on-Trent ..North Staffordshire Institute of Mining and Mechanical Engineers.

Warwick .....Natural History Society.

Watford, Herts ..Herefordshire Natural History Society and Field Club (Daniel Hill, Esq., Hon. Librarian, Herga, Watford, Herts).

Wigan .....Free Library.
Mining School.

II.—SCOTLAND.

Dundee .....Free Library and Museum.

Edinburgh .....Advocates' Library.
Edinburgh Geological Society.
Royal Society.
Royal Physical Society.

Glasgow .....Geological Society.
Natural History Society.

Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
The Library, Trinity College.

Belfast .....Natural History Society, the Museum.

IV.—Australia.

Adelaide.....Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne .....Geological Society of Australasia, Colonial Mutual Chambers.
Public Library of Victoria.
Australian Mining Standard, Monahan's Buildings, 231-3, Little Flinders Street.

Sydney .....Free Public Library.
Australasian Association for the advancement of Science, the University.
Royal Society of New South Wales, 37, Elizabeth Street.
Department of Mines.—The Honourable the Minister of Mines.

V.—Canada.

Halifax, Nova Scotia..... } Nova Scotian Institute of Science.

Hamilton, Ont...Hamilton Association.

Montreal.....Library of Canadian Mining Institute, Room 4, Windsor Hotel, Montreal.
M'Gill University (Principal, Sir J. W. Dawson, F.G.S.).

Ottawa .....Geological Survey of Canada (G. M. Dawson, C.M.G., LL.D., F.R.S., Director, Museum, Sussex Street, Ottawa).

St. John, N.B. ..Natural History Society of New Brunswick.

Toronto .....Canadian Institute, 58, Richmond Street, E.

VI.—India.

Calcutta ..... Geological Survey of India.

VII.—United States.

Baltimore .....The Maryland Geological Survey (The State Geologist, John Hopkins University).

Boston .....Free Library.

Cambridge, Massachusetts ..... } Museum of Comparative Zoology, Harvard College.

Chapel Hill, North Carolina ..... } The Elisha Mitchell Scientific Society.

Chicago .....The Chicago Academy of Science.
Field Columbian Museum, Zool. Series.

Columbus .....Ohio, Geological Survey of. (The State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana .....Department of Geology and Natural Resources (W. S. Blatchley, Esq., State Geologist).

Illinois .....Illinois Mining Institute, Springfield, Ill.
Field Columbian Museum, Chicago.

Michigan .....Michigan Mining School, Houghton.

Minneapolis ....Geological and Natural History Survey of Minnesota, Bulletin.

Jefferson City, Missouri.... } Missouri Geological Survey.

New York .....American Institute of Mining Engineers (R. W. Raymond, 99, John Street, New York City).
American Museum of Natural History, Central Park.

Philadelphia ....Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104, S. Fifth Street.

Scranton, Pa......Editor of "Mines and Minerals."

Washington ....Library of the U.S. Geological Survey.
Smithsonian Institute.

Wisconsin .....Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming .....Historical and Geological Society.

VII.—Foreign Societies.

Berlin.....Deutsche Geologische Gesellschaft.
Gesellschaft für Erdkunde. Wilhelmstrasse, 23, S.W.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres....Officiana Nacional de Commercie.

Caen .....La Société Linnénne de Normandie.

Christiania.....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gesellschaft Isis.

Halle, A/S.....Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors.....La Commission Gèologique de la Finlande. Dr. J. J. Sederholm, Boulevardsgatan 29.

Iglo, Hungary ..Societé Hongroise de Carpathe.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lausanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Lille .....Société Geologique du Nord.

Mexico.....Sociedad Cientifica "Antonio Alzate."

Naples.....Accademia della Scienza Fisiche e Mathematiche.

Paris .....La Société Gèologique de France.

Paris .....La Société de Spéléologie. 7, Rue des Grands Augustins.

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Academia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.

Stockholm .....Académie Royale Suedoise des Sciences.

Turin .....Acadêmie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 165, Strand, W.C.

Mining Journal, 446, Queen Victoria Street, London.

Colliery Guardian, 49, Essex Street, Strand, London.

Science and Art of Mining, 27, Wallgate, Wigan.

Stone, F. W. Hoyt, 45, Broadway, New York.

LIST OF MEMBERS.

NOVEMBER, 1900.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Walkden, R.S.O., Lancashire.
1884	Aldred, James, Bull Hotel, Ratcliffe.
1897	Allen, Edward, M.E., Willow Bank, Peel Causeway, Bowdon, Cheshire.
1898	Allen, Robert, 57, Meadow Road, Norah Street, Lower Broughton, Manchester.
1879	Arrandale, John Thomas, 82, Brook House Street, Wigan.
1893	Ashworth, John, C.E., 8, King Street, Manchester.
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton.
1895	Atherton, H., Stanley, 13, Mawdesley-street, Bolton.
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent. *Member of Council.*
1897	Baker, Godfrey, Pendlebury, Manchester.
1893	Bancroft, Robert E., 8, St. James' Square, Manchester.
1895	Barnes, J., F.G.S., South Cliff House, 301, Great Clowes Street, Higher Broughton. *Member of Council. Hon. Auditor.*
1875	Barrett, W. S., J.P., 64, The Albany, Old Hall Street, Liverpool. *Past-President.*
1891	*Bell, Thomas*, J.P., 15, The Valley, Scarborough.
1897	Bennett, F. F., M.I.E.E., 13, Victoria Buildings, Manchester.
1899	Bennett, Samuel B., 60, Gloucester Road, Urmston.

Year of Election.	Names and Addresses.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2 George's Square, Edinburgh.
1898	Boden, Peter, Butterworth Hall Colliery, Milnrow, Rochdale.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington. *Member of Council.*
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester.
1895	Brierley, Brandon T., F.G.S., Bellayre, Lymm, Cheshire.
1877	*Broeck, Ernest Von den*, 32, Place de l'Industrie, Brussels.
1897	Brooks, the Hon. William, J.P., Crawshaw Hall, Rawtenstall, Manchester.
1881	Bryham, William, Douglas Bank Colliery, Wigan.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, Manchester. *Past-President.*
1882	Caldwell, George, Moss Hall Collieries, Wigan. *Member of Council.*
1897	Caldwell, J. S., Westhoughton, Bolton.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1898	Clark, Geo. F., Bickershaw Collieries, Leigh, Lancashire.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1895	Coope, Samuel, Land and Mine Surveyor, Farnworth, Bolton.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, F.G.S., Mantcliffe, Horwich, Bolton. *Member of Council.*
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1862	Cross, John, 77, King Street, Manchester.

Year of Election.	Names and Addresses.
1900	Davidson, Robert, Clifton Vale House, Clifton, Manchester.
1869	Dawkins, Professor W. Boyd. M.A., F.R.S., F.G.S., F.S.A. The Owens' College, Manchester. *Past-President.*
1900	Deane, Adam, Stopes Colliery, Little Lever, Bolton.
1877	*De Rance, C. E.*, F.G.S., 32, Carshalton road, Blackpool.
1898	Dickinson, Archibald, Bank Hall Colliery, Burnley.
1856	Dickinson, Joseph, F.G.S., South Bank, Sandy Lane, Pendleton. *Past-President. Trustee.*
1889	Dobbs, Joseph, Coolbawn House, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan.
1898	*Eagle, George, Westminster Buildings, 37, Brown Street, Manchester.
1878	Ellesmere, the Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1897	Ellis, W. F. Wood, M.Inst.M.E., M.S.A., office of the Brewers' Confederation, 10, St. James' Square, Manchester.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1895	Evans, Robert, Mining Engineer, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, 4, Wellington Terrace, Lichfield Road, Sutton Coalfield.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1868	Fletcher, Thomas, Wheatfield, Bolton-le-Moors.
1873	Garforth, W. E., F.G.S., Halesfield, Normanton.
1893	Garside, Edward, B.Sc., Town Hall Chambers, Ashton-under-Lyne.

Year of Election.	Names and Addresses.
1874	*Geikie, Sir Archibald,* D.Sc., LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester. *Member of Council.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1899	Goodwin, John, Flattocks. Castleton, near Manchester.
1892	Grant, Frederick John, Bank Field, Burnley. *Member of Council.*
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1863	Greenwell, G. C., F.G.S., M.I.C.E., Elm Tree Lodge, Duffield, Derby. *Past President.*
1874	Greenwell, G. C., jun., M.Inst.C.E., F.G.S., Beechfield, Poynton, Cheshire. *President.*
1879	Greenwood, John, c/o The Globe Spinning Company, 1, Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., F.G.S.A., 348, West 8th Street, Erie, Pennsylvania, U.S.A.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, Inspector of Mines in India, 27, Chowringhee Road, Calcutta, India.
1897	Guy, J. G.
1881	Hall, Henry, H.M. Inspector of Mines, Rainhill, S. O. Lancashire. *Past-President.*
1898	*Hall, Levi J., Morland House, Birch Vale, near Stockport. (Furness Vale Collieries, Stockport.)
1897	Hall, William, B.Sc., Science Teacher, 44, Arrowsmith Terrace, Bolton.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1897	Harris, George E., M.E., Assam Railway and Trading Co., Limited, Margerita, Assam, India.

Year of Election.	Names and Addresses.
1894	Harrison, George B., H.M. Inspector of Mines, 278, Worsley Road, Swinton, Manchester. *Member of Council.*
1892	*Haworth, Denis, Oswaldwistle Collieries, Accrington.
1894	Hayward, John, Ladyshore Colliery, Little Lever, Bolton.
1897	Heather, Frank, 35, Dickinson Street, Manchester.
1900	Henshaw, A. M., Talk-o'th'-Hill Collieries, Staffordshire.
1889	Higson, Charles H., 106, Eccles Old Road, Pendleton, Manchester.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1900	Hinnell, Leonard H., Civil Engineer, 41, Corporation Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 37, Cross Street, Manchester. *Hon. Treasurer.*
1899	Hollingworth, David, 2, Hulme Place, Crescent, Salford.
1895	Holroyd, W. F., F.G.S., River Cottage, Lower Broughton. *Vice-President. Hon. Librarian.*
1897	Howain, Evelin G., Huntroyd Estate Office, Padiham.
1884	Hughes, Owen, 48, Hall Lane, Hindley, near Wigan.
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1895	Hutchinson, John William, Bamfurlong Collieries, Wigan.
1887	Jackson, Andrew.
1878	Jackson, Charles G., Rookwood, near Chorley.
1898	James, Isaac, Wigan Junction Collieries, Abram, Wigan.
1883	Jobling, Albert, 91, Rectory Road, Burnley.
1883	Jobling, Henry, 91, Rectory Road, Burnley.
1884	Jobling, John, Manager, Cliviger Colliery, Burnley.
1900	Jobson, Henry, Mining Student, Bank Hall Colliery, Burnley.
1882	Johnson, William, Abram Colliery, Wigan.

Year of Election.	Names and Addresses.
1887	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P., Gawthorpe Hall, Burnley. *Past-President.*
1897	Keen, James, Hindley Green, Wigan.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lees, M.A., LL.M., M.P., Westwood, Pendlebury. *Trustee.*
1898	Krauss, John Samuel, B.A., Whitecot, Wilmslow, Cheshire.
1898	Landless, Richard, Bank Hall Colliery Burnley.
1898	Laverick, John H. W., Pye Hill, near Nottingham.
1890	Law, J. Illingworth, Waterfoot, Manchester.
1900	Lawson, A. C., Carrisbrooke House, Osborne Road, Levenshulme.
1899	Leah, Richard, Smedley Road, Cheetham, Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1897	Lees, Frederick, The Rookery, Ashford, Bakewell.
1899	Leigh, Oswald B., Westbourne, St. Annes-on-Sea.
1894	Lindsey, Charles R., B.Sc., 509, Edge Lane, Droylsden, Manchester. *Vice-President.*
1898	Livesey, John, 117, Stoneclough Road, Stoneclough, Manchester.
1898	Lomax, James, 65, Starcliffe Street, Moses Gate, Bolton.
1877	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Bower Colliery, Hollinwood, near Oldham.
1881	Macalpine, G. W., Parkside, Accrington.
1897	McCallam, Theo. S., C.E., 4, Chapel Walks, Manchester.
1890	McGeever, James, Garswood Hall Colliery, Wigan.
1897	Makepeace, H. R., H.M. Inspector of Mines, Trentham, Stoke-on-Trent,
1891	Marshall, Herbert S., Arnoldsmere, Freshfield.

Year of Election.	Names and Addresses.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Member of Council.*
1893	Matthews, E. L., Belvedere Street, Withington Street, Pendleton, Manchester.
1896	Matthews, Thomas, Imperial Iron Works, Belvedere Street, Withington Street, Pendleton, Manchester.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Clifton, Bristol.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham.
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Oakwood, Walkden, Bolton. *Member of Council.*
1895	Mort, Arthur, B.Sc., Sharigh, Baluchistan, India.
1878	Nall, Simon, Newbold, Rochdale.
1898	Naylor, Alfred, Cotes Park Colliery, Alfreton, Derbyshire.
1897	Nelson, William. jun., Clifton and Kearsley Collieries, Clifton, Manchester.
1897	Noar, L. Lamb, The Grove, Lymm.
1900	Ollerenshaw, W., Manager, Denton Colliery, Denton, Manchester.
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Whitehouse, Nailstown Colliery, near Leicester.
1876	Peace, George, Monton Grange, Eccles. *Vice-President.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1897	*Pickup, P. W. D., Rishton Colliery, Rishton, nr. Blackburn.
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*

Year of Election.	Names and Addresses.
1899	Pilkington, Lawrence, South Garth, Eccles Old Road, Pendleton.
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S., Moss House, Kings Road, Rochdale. *Member of Council.*
1891	Prestwich, Joseph, Elm Bank, 72, Eccles Old Road, Pendleton, Manchester.
1897	Reid, Alexander, Dover Collieries, Dover.
1900	Rhodes, John R., Gorphwysfa, Prestwich.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.
1860	Ridyard, John, F.G.S., Hilton, Bank, Little Hulton, Bolton. *Past-President.*
1893	Rigby, John, Highfield, Winsford, Cheshire. *Member of Council.*
1897	Ritson, W. A., 44, Woodlands Street, Cheetham, Manchester.
1889	Robinson, John, Haydock Collieries, St. Helens.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1898	Roscoe, Thomas, Peel Hall Collieries, Little Hulton, Bolton.
1895	Rothwell, Samuel, Silverwell Street, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Past-President. Hon. Secretary.*
1888	Scarborough, George Edward, Colliery Manager, Newton and Meadows Collieries, Wigan.
1897	Scholes, Thomas, 25, Crossley Street, Longsight, Oldham.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, Redthorpe, Bromley Cross, near Bolton.

Year of Election.	Names and Addresses.
1899	Selby, John B., Atherton House, Leigh, Lancashire.
1882	Settle, Joel, The Hill, Alsager, Stoke-on-Trent.
1878	Settle, Miles, Rosslymn, Lytham Road, Blackpool.
1889	Settle, William, Brunswick House, Haulgh, Bolton.
1899	Shaw, Alfred, Bersham Colliery, Wrexham.
1884	Shaw, David, Norbury Moor, near Stockport.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1894	Slee, John, Engineer, Earlestown.
1864	*Smethurst, William, F.G.S., Brynmair, Dolgelly, N.Wales.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., Assoc.M.Inst.C.E., Thrale Hall, Streatham, Surrey.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Past-President.*
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1899	Tansley, A. E., Springfield House, Coppull, Chorley.
1899	Tatham, Roger, 51, Oxberry Avenue, Fulham, London, S.W.
1889	Taylor, William, 51, Park Road, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 18, Wood Street, Bolton.
1892	Thompson, James, 248, Chorley Road, Westhoughton, Bolton.
1897	Tickle, James, Abram Collieries, Bickershaw, Wigan.

Year of Election.	Names and Addresses.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Bridgewater Foundry, Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President.*
1898	Tonge, James, Jun., F.G.S., 21, Mawdsley Street, Bolton. *Hon. Secretary*
1886	*Trafford, Sir Humphrey Francis de, Bart., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Church Street, Leigh, Lancashire.
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1896	Turner, William, Sherdley Collieries, St. Helens.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26 Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.
1888	*Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1897	Walton, Thomas, Habergham Colliery, Burnley.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich.
1880	Watts, William, F.G.S., Underbank Hall Deepcar, near Sheffield. *Past-President.*
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester. *Vice-President.*
1877	West, T. E., Union Street, Oldham.

Year of Election.	Names and Addresses.
1890	*Whittaker*, *William*, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.
1891	Whitehead, J. J.
1898	Widdowson, J. H., 19, Brazenose Street, Manchester.
1867	*Wild*, *George*, Albert Street, Bardsley, Ashton-under-Lyne.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Hon. Auditor.*
1876	Winstanley, Robert C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.
1897	Wood, Percy Lee, Newtown Collieries, Clifton, Manchester.
1898	Woodeson, W., 57, Roseneath Road, Urmston.
1876	Woodward, H. A., Whitville, Kidderminster.
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

SUBSCRIBERS.

Stechert & Co., 2, Star Yard, Carey Street, London, W.C.

Eyre & Spottiswoode, 5, Middle New Street, London, E.C.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any omissions, or corrections required in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XXVII. SESSION 1900-1901.

The ORDINARY MEETING of the Members was held on Tuesday, November 13th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

In the absence of the President (Mr. G. C. GREENWELL) through domestic bereavement, the Chair was taken by Mr. JOSEPH DICKINSON, a past President.

DEATH OF MR. G. C. GREENWELL, SENR., AND MR. CALDWELL.

The CHAIRMAN referred in sympathetic terms to the loss which the Society had sustained by the death of Mr. G. C. Greenwell, Senr. (father of the President), and of Mr. George Caldwell. He said that in Mr. G. C. Greenwell, Senr., they had lost not only an ordinary member, but a valuable and useful member; one who was always ready to give them some information on points that were passing in connection with mining. And he, when needed, illustrated what he had to describe by some very ingenious models. They had lost also, he saw, by death, another useful member, Mr. George Caldwell. In an unostentatious way, Mr. Caldwell was always ready to let members of the Society know what was going on in the numerous coal

mines in which he had an interest. In the sinking of the Maypole new winning at Abram, he laid the works open to this Society, so that they might see the sinking down through the wet strata of the Permian, and he sent the Society specimens likely to be interesting on several occasions. He moved that the Meeting express its sympathy with the families of the deceased members.

Mr. JAMES TONGE, Senr., seconded the proposal, and it was adopted.

NEW MEMBERS.

The following gentlemen having been duly nominated were balloted for and were unanimously elected Members of the Society :—

THOMAS BANKS, Civil and Mining Engineer, 60, King Street, Manchester.

RICHARD BRANCKER, 11, Old Hall Street, Liverpool.

HARRY BURKE, 47, Albion Street, Brook's Bar, Manchester.

ABRAHAM ELCE, Junr., Colliery Manager, 88, King Street, Dukinfield.

FRANK MAXWELL, Architect and Civil Engineer, 41, Corporation Street, Manchester.

WILLIAM PICKSTONE, 11, Brighton Grove, Rusholme.

GEORGE RIDYARD, Mining Engineer, Bruntscar, Westhoughton.

NOTES—GEOLOGICAL AND INDUSTRIAL—FROM THE PARIS EXHIBITION, 1900.

The Great Siberian Railway.

Mr. Mark Stirrup, F.G.S., said, it was only a week ago that he got a note from the Secretary asking him to prepare something for this meeting, as the President was not likely to be at the meeting to give them the address which, as a rule, they expected from a new President. He had therefore put together a few notes of some of the things which occupied his attention during a recent visit to the great Exhibition at Paris, as a member of the International Geological Congress and hoped they would be interesting to the meeting. But before he passed on to the notes on the Great Siberian Railway he wished to show some specimens which he got in the neighbourhood of Paris during one of the numerous excursions that took place in connection with the Geological Congress. One of the excursions which he accompanied was to the gypsum quarries at Romainville, in the vicinity of Paris, and he brought away with him some specimens of that variety of crystalline gypsum, known as the "fer-de-lance" or arrow-head type, a speciality of the Parisian gypsum beds and which he now had the pleasure of showing to the meeting.

The Chairman asked how the translucent gypsum was found in the mines—did it lie embedded in the rock?

Mr. Stirrup answered in the affirmative.

The Chairman noted the resemblance of the other specimens to selenite.

Mr. Stirrup said it was the same thing.

The Chairman said that in the Sussex mines the selenite lay at the bottom of the bed half an inch to six inches in

thickness, and very often where the selenite was thick the mineral about was poor.

Mr. STIRRUP said the gypsum was not confined to one bed. There were several beds of it interstratified with clays and marls; these gypsum beds were also notorious for containing the bones of extinct animals. It was on the bones which were found in these gypsum beds, that the great Cuvier worked for several years in the restoration of the extinct species of the Tertiary fauna. Mr. Stirrup exhibited, as a specimen, a portion of a small jaw-bone which he had picked up in one of the quarries.

The CHAIRMAN (after examining the specimen): Are we to take this as a natural fossil or a petrifaction?

Mr. STIRRUP: It is a fossil bone, part of a jaw bone of some small animal. Mr. Stirrup also referred to some beautiful exhibits at the Champ de Mars of petrified wood from Arizona, the remains of a forest of large coniferous trees, which had fallen and become silicified on the spot, a wood-cut of which was shown. There were tons weight of these tree trunks, showing the condition in which they are found on the surface of the soil in Arizona. The mineralized wood shows a great variety of colours as in agates, and is of extreme hardness, and when polished is of a highly ornamental character.

Another excursion was to those celebrated fossil shell beds at Grignon, near Paris, where Tertiary shells of Eocene age are found in large numbers and perfection. If of sufficient interest to the members, I can, on some future occasion, exhibit a collection from these beds. For the present, I thought these specimens, which I have brought, would be specially interesting.

Turning to the main subject of his address—the great Siberian Railway—Mr. Stirrup submitted a great number of sketch maps of the new railway, and of the country through which it passes. Speaking of the railway itself, he said:

The Great Siberian Railway.

At the meeting of the Geological Congress in the Congress Hall, within the Exhibition Grounds, Paris, much literature was distributed having reference to the mineral and geological exhibits and the resources of continental states, the colonial possessions of France and Great Britain; notably among the latter, were reports of the Canadian Provinces, Nova Scotia, Klondyke Gold Fields, Western Australia, &c.

Since my return home, a thick volume on the mines of Japan, issued by the Japanese Government, has also reached me showing increased activity in the mineral output of that country.

Among the books and pamphlets referred to were a "Summary of the Geological and Mining Operations, the length of the Trans-Siberian" issued by the Committee of the Trans-Siberian Railway and a pamphlet being a "Sketch of the History of the Great Siberian Railway" edited by the Chancery of the Committee of Ministers. It is from these government sources that I draw for the principal facts that I purpose to put before you.

The results of the geological explorations in the gold regions of Siberia are not yet published but are in the printer's hands.

Siberia, with whose name many painful stories of Russian rule are associated, occupies the whole northern part of Asia and forms a large part of the Russian Empire. Mere figures fail to give an idea of its vastness, which is better comprehended by the aid of good maps.

It covers an area of 14½ million square kilometres, *i.e.*, about one-ninth of the whole continental surface of the globe, and over one-fourth of Asia. It is 2½ times larger than European Russia, and half as large again as the whole of Europe. The vastness of the area accounts for the great variety in its nature and climatic conditions.

The northern portion of this territory is unfit for agriculture or colonization in consequence of the severity of its climate and its constantly frozen sub-soil. On the other hand the region traversed by the new Siberian railway embraces the more populous southern portion of Siberia, where the climate is more favourable to agriculture and colonization.

The character of this immense country will perhaps be better understood if I read a few paragraphs from one of the publications which I mentioned as being distributed at the Congress.

"Geographically, Siberia may be divided into (1) Western Siberia, containing the provinces of Tobolsk, Tomsk, Toorgaï, and Uralsk Steppe territories; (2) Central Siberia, with the Yenisei and Irkutsk provinces; and (3) Eastern Siberia, *i.e.*, the Yakutsk territory and the Amoor region, consisting of the Trans-Baikal, the Amoor and the Coast territories, including the Island of Saghalien.

Western Siberia embraces the vast plain occupied by the basin of two mighty rivers—the Ob and the Irtish—and it is only in the south that there are any mountain ranges. The central, agricultural portion of this extensive territory has long been the principal region in which emigrants from European Russia have settled, attracted by the favourable climate and soil, similar to those of Central Russia. Emigrants are particularly attracted by the Altai mining district, which occupies the southern part of the Tomsk province, and is the private property of His Majesty the Tsar. The south-eastern part of this district is occupied by a range of mountains, over 10,000 feet above sea level, intersected by valleys, and contains the most important mineral wealth of Western Siberia; gold, silver, copper, precious stones, and iron, with rich beds of coal have been discovered here.

The provinces of Central Siberia—Yenisei and Irkutsk—lie in the basin of the river Yenisei, and differ from the plains of Western Siberia in being covered by the low spurs of the Sayan Hills, which form the boundary between Russia and China. The climate of this region is somewhat colder than that of Western Siberia. On its eastern borders the province of Irkutsk has the Baikal Lake, the largest stretch of fresh water in the Old World, being over 400 miles long, and from 24 to 56 miles broad, its total area covering about 13,000 square miles. The river Angara, which flows from the western part of the lake, connects it with the river Yenisei. These provinces are rich in gold, silver, copper, iron, &c.

Finally, the Amoor and Coast territory embraces the whole of the Russian portion of the Amoor basin and all the coast of the seas of Japan and Okhotsk and the Behring Sea, including the extensive Kamtchatka peninsula, and the island of Saghalien.

The Trans-Baikal territory with its mountain ranges, is distinguished for its continental climate, much colder than that of the Cis-Baikal region of Siberia. Nevertheless, in the south (up to about 53° N.) there are valleys splendidly cultivated by the Russian population and abundantly irrigated by the rivers of the Baikal basin, likewise steppes which afford excellent pasturage for the flocks and herds of the nomadic tribes and of the Russian Cossacks who inhabit the country bordering on China.

In addition to possessing such a favourable soil, the Trans-Baikal is distinguished for the abundance of its mineral wealth, such as gold, silver, copper, besides tin, quicksilver and beds of coal."

Such are, in broad outline, the main characteristics of Siberia as drawn by the Russian Ministers themselves.

This great project of a Trans-Siberian railway, stretching

from the confines of Europe eastwards to the Pacific, was determined upon during the reign of the late Emperor of Russia, Alexander the Third, and the present Emperor, Nicholas the Second, laid the first stone, 19th May, 1891, at Vladivostok on the shores of the Pacific ocean, now a considerable commercial Port. At the time the construction of the railway was first decided upon, the geological constitution of the immense stretch of territory that it was destined to pass through, was for the most part unknown, except in the neighbourhood of those places where mining industries had already been commenced.

The formation of the railway necessitated the study of the geology of the country—the constitution of the soil, the supply of water, materials of construction, combustibles and other minerals—not only for the needs of the railway, but in order to contribute to the prosperity of the mines and works that it was hoped would be rapidly developed in Siberia after the opening of the railway.

From the year 1888 and onwards, various expeditions were sent out and equipped under the authority of the Department of Mines to geologically explore along the line of country which has been marked out for the railway.

Reports of these explorations have been published from time to time in the Journal of Mines, in the Bulletins of the Society of the Mining Engineers of Russia and elsewhere.

The principal result which these expeditions were expected to attain was a knowledge of the geological structure of the countries on either side of the projected railway, the chief rivers traversing the line &c., in order to construct a geological map of the territories and then to proceed to the exploration in detail of deposits of coal, iron, gold, &c.

In the geological survey, special attention was turned to the discovery of coal beds, in order to supply the railway with fuel, as a principal part of the country traversed is

without timber; the researches of the mining engineers were successful in finding a number of coal beds along the railway route, as well as some lying at a distance.

Other useful minerals were sought for, iron-ore being found in the Trans-Baikal; copper in the Steppe territory; nephrite in the Province of Irkutsk, also various building materials.

Special expeditions were dispatched in search of workable goldfields, such have been discovered along the river systems of the Yenisei, the Lena, and the Amoor Coast.

In connection with the railway undertaking, other subsidiary enterprises were promoted, which had for their object the encouragement of colonization by emigrants from European Russia, as well as the industrial development of Siberia.

The great Siberian rivers have been surveyed, in order to improve their navigable qualities, so that they may act as feeders to the railway. An investigation of Lake Baikal, which traverses the line of railway, one of the deepest fresh-water basins of the world, was also undertaken, and the survey, it is stated, will have great influence in the development of the coast, lighthouses having been built on four most important points.

The river Yenisei is said to have no bar, and is navigable to ocean steamers for 1,000 miles from its mouth, and that the river Ob is open from the sea to vessels drawing up to 12 feet of water.

All these great national works have not been carried out, without a large expenditure of Imperial funds. The total cost of the Siberian railway, constructed by Russians, and with Russian money—with all its branches and auxiliary undertakings connected with it—amounts to £78,000,000, of which over £50,000,000 were expended by 1900, and about £13,000,000 have been assigned for the present year, 1900.

Of the present condition of the Siberian railway and the results of recent working, a few paragraphs from the official pamphlet, from which I have previously quoted, will give the best idea.

"In the interests of transport and with the object of rendering this stupendous undertaking as inexpensive as possible, the shortest and most direct route was selected, for the most part coinciding with the 55 parallel, and traversing the most fruitful and comparatively populous belt of country—the granary of Siberia. The Siberian railway was begun at both ends, its western terminus being Tcheliabinsk, the last station of the Samara-Zlatooust Railway, and a district town in the Province of Orenburg. By 1900 (*i.e.* less than nine years of construction) 3,375 miles of line were laid, making 375 miles a year. Such results must be considered as very favourable, especially taking into account (1) the difficulty of laying the permanent way in a country so intersected by rivers as the provinces of Tomsk and Yenisei, and so liable to inundation as the Trans-Baikal region; and (2) the great number of large rivers to be crossed by the Siberian railway, over 30 miles of bridges being required for this purpose. The longest of these bridges is that over the river Yenisei, it is 2,940 feet long, with spans measuring 490 feet. When the navigation is open in 1900 there will be the possibility of direct steam communication between the European railways and Vladivostok, partly by rail and partly by steamer, by the following route: From Tcheliabinsk to Sretensk by rail (2,762 miles), crossing Lake Baikal (40 miles) by means of an ice-breaking steamer, specially adapted for ferrying the whole train across; from Sretensk to Khabarofsk by steamer down the rivers Shilka and Amoor (1,442 miles), and finally from Khabarofsk to Vladivostok again by rail (478 miles). This journey will take about two and a half weeks. To facilitate travelling by

the Siberian railway, a special express service has been established between Moscow and Irkutsk, the trains starting every week. These trains have sleeping-cars, a dining-car, library, bath, and gymnasium, and excel the best express trains of Europe in the comforts afforded to passengers. The journey from Paris or London to Vladivostok through Siberia now takes about three and a half weeks, while the journey by sea, viâ the Suez Canal, takes about six weeks. Communication will be still easier on the completion of the Circum-Baikal section (157 miles), begun in 1899, as well of the Eastern Chinese or Manchurian line (960 miles). When these two lines are completed there will be *direct railway communication between the Atlantic and Pacific Oceans*, through Europe and Asia. The total length of the Great Siberian Railway, with the Manchurian and other branches, will be 5,542 miles."

The results of the working of the Siberian railway from October, 1885, when the Southern and Central Sections were open for traffic, to 1899, when the whole line between Tcheliabinsk and Irkutsk was in operation, have exceeded all expectations.

In addition to the impulse given to the industrial development of Siberia by the Trans-Siberian Railway, there are many scientific questions of extreme interest to geologists and others, which, it is to be hoped, will receive elucidation from the explorations in Southern Siberia, notably, the history of its river system, the origin of the dreary region of the Steppes, and of the numerous salt water or brackish lakes which dot them.

In the Kirghis Steppes a great number of saline lakes occur, some of which yield salt which is collected by the nomadic tribes. In some of these the water is very shallow, and little salt is deposited. In one instance, however, a continuous layer is deposited, at times reaching to a deposit of ten inches.

These lakes are now undergoing desiccation, showing that some change in climatic conditions is being gradually brought about.

The lacustrine period in the Trans-Baikal region is said to be of Post-Tertiary date, when the spread of these lakes covered all the valleys to a considerable height. At this time the territory above the level of the waters suffered an intense erosion, the vestiges of which are visible in beds of large and small stones, constituting the lower horizons of the stratified post-pliocene alluvia.

The deposits of the second half of that period consisted solely of sands and here and there shaly clays, which are now suffering erosion, forming wind-driven deposits of loess and alluvium.

The geological report, from which I have drawn, goes on to say that the fluvial network, which existed before the epoch of the Tertiary lakes, differed notably from those of to-day, and that even the direction of the water-courses is often changed, owing to the passages which the rivers have carved for themselves, and which are cut in many points across the hard rocks, in the neighbourhood of ancient valleys occupied by the lacustrine deposits.

With regard to the search for combustible materials, different types of coal and lignite and bogheads were met with. Deposits of coal of carboniferous age resting on Devonian rocks, several beds two to three métres thick; one mine is now furnishing monthly 5,000 tons of coal to the Trans-Siberian Railway. Other coal deposits are said to be of Jurassic age, but the numerous deposits of lignite are for the most part Tertiary, and as a rule lie upon beds of clay. Some of these lignite beds are very thick.

The CHAIRMAN: Mr. Stirrup has very cheerily taken us over immense tracks of country, across great rivers, through great cities, and over a fresh water lake as large as Ireland, or larger. He has told us of the geological features of the country, through which this great railway passes; and if he has done nothing else he has given us some food for reflection. It was interesting to think of the vast tracts of country, and the stores of mineral wealth, ready to be opened up in Russia, which, if wisely administered, must hereafter become of vast importance. We know that Mr. Stirrup is a member, not only of the Geological, but of the Geographical Society; and he talks with greater fluency of those vast tracts of country, than, perhaps, some of us are able to follow him, but we all beg to thank him, I am sure, for his interesting discourse, and I move a resolution accordingly.

Mr. SAINT seconded the proposal, and it was carried with acclamation.

The CHAIRMAN said he supposed the ice-breaker referred to by Mr. Stirrup was the one sent out by Armstrong, Whitworth & Co.

Mr. STIRRUP said there were several of these ice-breakers now in Russia. He remembered there was one in use in Finland.

The CHAIRMAN: Do you know how they act?

Mr. STIRRUP: No. I can't say, because I did not see them working.

The CHAIRMAN: One has heard of men hanging in front of a vessel from the bowsprit and literally cutting the ship's way with axes.

Mr. STIRRUP: I have not seen the ice-breakers at work, but I know they are extremely useful in keeping the

Finland ports open, which would otherwise be inaccessible during the winter.

Mr. LEAH said he understood that the principle on which the ice-breaker worked was to force a great volume of water into the air and let it fall on the ice.

The CHAIRMAN remarked that the mountains mentioned by Mr. Stirrup were the same as those named by Sir Roderick Murchison many years ago as likely to be gold-bearing.

Mr. ATHERTON invited Mr. Stirrup to state the position in which he found the gypsum specimens. He had often seen gypsum and he thought it would be more convenient to have it properly located. If we knew the horizon where it was found in one place under its proper geological name it was easier to correlate it afterwards. As to the period occupied in the construction of the Siberian railway, he might mention that the Canadian Pacific Railway was laid in eight years, and traversed in places 5,100 feet altitude. He did not think the difficulties encountered by the Russian engineers exceeded those met with in the construction of the Canadian Railway. When one saw the powerful engines required to take a train up the steep inclines—two in front and one behind—and that four engines were needed for the down-coming, one realised the difficulties of the position and learned that it was more difficult to descend than to ascend.

Mr. PICKSTONE said he had picked up numerous fine specimens of gypsum in the boulder clay on the Dee. There was no coal in the boulder clay on the Dee, and there was no gypsum in any other boulder clay that he had seen.

Mr. STIRRUP, replying to Mr. Atherton, said there were two well-known formations in which gypsum occurs. One was the Trias in connection with rock-salt, and the other the Tertiary. The former occurred in our own neighbourhood, and in Staffordshire, Nottinghamshire, and elsewhere—where gypsum was found, not perhaps in the condition of the Paris specimens, but more massive. It took upon itself several forms, but this special form of lance-head crystallisation had not, so far as he was aware, ever been found in the Triassic rocks. The specimens he had shown were from the Romainville quarries, within a few miles of Paris, and their geological position was really among the Eocene rocks or the Lowest Tertiary. The character of these plaster quarries, as one might call them, was seen in the little sketch he sent round. The gypsum deposits occurred interstratified among clays and marls which were dug out for the purpose of making cements. He understood that the special kind of gypsum got from these Parisian quarries was much stronger and had special properties for making firmer the cements that were used for plaster ceilings and other work. He thought someone asked him about the coal beds of the Trans-Siberian. The special geological position of many of them was at present undetermined. Of course in a country like Siberia there were few sections to be had. Most of the country was flat, and therefore nothing like that of the Canadian Pacific Railway. But some of the coal beds had been pronounced to be of the carboniferous age, and others were said to be of Jurassic age. Some beds were spoken of as not fit for steam uses, but they were all made use of, no doubt, one way or another. The Boghead coals, which were said to be formed of algal vegetation, and the Lignites, had been found in thick deposits in many districts along the line of railway, and they were probably for the most part of Tertiary age.

Mr. ATHERTON: I understand that in certain places, in the locality of the coal, they have come across crude petroleum. Did you make any note of that?

Mr. STIRRUP: I think it quite likely petroleum will occur somewhere, but I have not come across any definite statement in regard to it. Certainly in these sketches I have read, nothing of that kind has struck me.

Mr. ATHERTON: It is not in the same formation as they find it in the South of Russia?

Mr. STIRRUP: It may be found, as a rule, in any formation, if you have the material deposited there from which the petroleum may be distilled.

With regard to the gold explorations Mr. Stirrup said there had, of course, been great endeavours to find workable gold fields, and some were already in hand. Most of the gold that had been found occurred among the Archean and older crystalline rocks, and in the alluvial valleys draining them, where it would be worked in the fashion of gold placers for years to come. All over the Amoor coast region, gold had been found. In his opinion it might be looked for in most of the river valleys which had their source in those high regions of granite and archæan rocks of the Trans-Baikal and the Amoor.

SECTION OF STRATA AT SOUTH CARR, LINCOLNSHIRE.

Mr. Lionel B. Wells, M.Inst.C.E., sent for inspection the details of a section of strata above the Barnsley coal, passed through in the bore hole at South Carr, Lincolnshire, under the direction of Messrs. A. Wilson and G. Dunstan. Mr. Wells sent word that he was detained on business, in London, so could not attend the meeting.

The CHAIRMAN explained that the situation of the strata in question was mid-way between Doncaster and Gainsborough, close to the north side of the River Idle, a short distance to the west where it joins the River Trent. The section sent by Mr. Wells showed that the Yorkshire coalfield was extending.

On the motion of the CHAIRMAN, seconded by Mr. SAINT, it was resolved to print the details of the section in the Transactions of the Society.

The CHAIRMAN said some opinions had been expressed that the very flat country in that part of Lincolnshire would not permit of complete mining operations. If the whole of the coal, it was said, were worked out the surface would subside and the land would be submerged. There would have to be extensive pumping operations, or they would have to leave sufficient coal to support the surface.

SECTION OF STRATA ABOVE THE BARNSLEY COAL

PASSED THROUGH IN THE

BORE HOLE AT SOUTH CARR, LINCOLNSHIRE,

Completed July, 1893, under the direction of Messrs. A. Wilson and G. Dunston.

Boring done by Messrs. Vivian Diamond Boring Co., Ltd.

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.			
			Soil	0	1	6			
			Sand	2	2	0			
			Sand and Clay	2	0	6			
			Sandy Clay	1	0	6			
			Sand	3	0	0			
			Sandy Clay	0	0	6			
10	2	0	Sand and Gravel	1	0	0			NEW RED SANDSTONE.
			Red and Blue Marl	1	0	0		UPPER	
			Red and Blue Marl, with Gypsum	3	1	6			
			Grey Sandstone	0	1	0			
			Grey Limestone	0	1	6			
			Red and Blue Sandy Marl, with Gypsum	13	1	7			
			Red and Blue Marl, with Gypsum	1	1	0			
			Blue Marl, with Gypsum	5	0	0			
			Red and Blue Marl, with Gypsum and Sandstone	8	0	0			
45	2	7	Red Marl	2	0	0	KEUPER.		
			Red and Grey Sandstone	35	0	8		LOWER	
			Red and Grey Sandstone, with Marl	10	0	11			
			Red and Grey Sandstone	52	2	1			
			Red and Grey Sandstone, with Blue Shale	11	1	0			
			Red and Grey Sandstone	5	0	0			
			Red and Grey Sandstone, with Shale and Marl	32	2	4			
			Red and Grey Sandstone	4	1	0			
			Red and Grey Sandstone, with Shale and Marl	26	0	1			
248	2	2	Red Sandstone	25	0	6			
			Red Sandstone, with Pebbles	68	2	10	BUNTER.		
			Red Sandstone, with Pebbles and Marl	3	1	0			
			Red Sandstone, with Pebbles	18	1	1			
343	0	7	Red Sandstone, with Marl	3	2	6			
			Red Sandstone	11	2	5			
			Red Sandstone, with Marl	38	1	6			
394	1	6	Red and Grey Sandy Marl, with Gypsum	1	0	0			

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.		
			Red Marl, with Gypsum	1	1	0	UPPER MARLS.	PERMIAN.
			Anhydrous Gypsum	2	2	10		
			Hard Red Sandy Marl, with Gypsum.	0	2	8		
			Hard Red and Grey Marly Sandstone, with Gypsum	1	0	6		
			Red and Grey Sandy Marl, with Gypsum	1	1	3		
			Red Marl, with Gypsum	5	2	6		
			Red Marl, with Gypsum and Limestone	3	0	0		
			Red and Brown Marl, with Gypsum and Limestone	1	2	4		
423	0	5	Fine Grey Sandstone, with Gypsum	10	0	10		
440	2	5	Grey Limestone	17	2	0	UPPER MAGNESIAN LIMESTONE.	
			Blue Marl, with Gypsum	2	1	2	MIDDLE MARLS.	
			Red Marl, with Gypsum	14	2	8		
			Rotten Red Marl, with Gypsum	4	2	0		
			Blue Marl, with Gypsum	1	0	0		
			Rotten Red Marl, with Gypsum	3	2	11		
			Brown and Blue Marl, with Gypsum.	17	1	0		
486	1	8	Brown Marl, with Limestone	1	1	6		
			Limestone, Red and Blue Marl, with Gypsum	3	2	6	LOWER MAGNESIAN LIMESTONE.	
			Grey Limestone	6	0	4		
			Grey Limestone, with Shale	9	1	7		
			Light Grey Limestone	3	0	0		
			Grey Limestone, with Shale	61	2	8		
			Grey Shale	4	0	0		
			Mottled Shale	1	0	0		
576	0	3	Red Shaly Limestone	0	0	6		
			Mottled Sandy Shale	1	2	0		
			Mottled Shale	1	1	0		
			Red and Grey Sandstone	2	1	0	ROTHERHAM RED ROCK.	
			Mottled Shale	1	0	0		
			Red and Grey Sandstone	15	2	1		
			Coarse Red Sandstone	0	2	6		
			Grey Sandstone	9	0	2		
			Blue Shale and Grey Sandstone	2	2	0		

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
611	0	3	Coal	0	1	3
			Fire-clay and Ironstone nodules	1	1	6
			Black Shale	0	1	6
			Blue Shale	5	0	6
			Grey Sandstone and Blue Shale	0	1	6
618	2	8	Coal and Black Shale	0	0	5
			Dark Blue Shale and Ironstone nodules	7	1	3
626	1	11	Coal	0	1	0
			Soft Grey Fire-clay (Coal 0 ft. 10 in.; Black Shale, 0 ft. 2 in.)	0	2	0
			Blue Sandy Fire-clay and Ironstone nodules	5	2	0
			Blue Sandy Shale	4	1	0
			Grey Sandstone	2	1	6
			Dark Blue Shale	0	2	6
642	2	3	Shafton Coal (Fire-clay, 1 ft. 7 in.; Coal 3 ft. 1 in.; Fire-clay, 1 ft. 8 in.)	2	0	4
			Grey Sandstone and Sandy Shale	2	1	0
			Dark Blue Shale	2	0	10
			Dark Blue Shale and Ironstone nodules	3	0	1
			Grey Sandy Shale	7	1	8
			Grey Sandstone	0	1	9
658	2	3	Coal	0	0	8
			Fire-clay and Ironstone nodules	4	1	5
			Dark Blue Shale	2	0	0
			Grey Sandstone	0	0	7
			Dark Blue Shale	5	1	0
			Fire-clay and Ironstone nodules	2	1	7
			Blue Shale and Ironstone nodules	6	0	3
			Blue Sandy Shale	9	0	0
			Grey Sandstone	11	0	0
			Dark Sandy Shale	0	1	0
			Grey Sandstone	4	0	6
			Grey Sandstone and Shale	2	2	0
			Dark Shale and Ironstone nodules	2	1	6
			Fire-clay and Ironstone nodules	11	1	5
			Blue Shale	1	1	5
			Fire-clay and Ironstone nodules	3	0	7
			Fire-clay	7	1	0

Depth from Surface. Yds.	ft.	in.	Name of Strata.		Thickness of Strata. Yds.	ft.	in.
733	0	7	Bagshaw Coal ..	Black Shale, 0 ft. 6 in. Coal .. .. 1 ft. 7 in.	0	2	1
			Fire-clay		3	0	6
			Grey Sandstone	OAKS ROCK	13	0	9
			Blue Sandy Shale	OAKS ROCK	0	1	6
			Grey Sandstone	OAKS ROCK	17	1	4
			Blue Sandy Shale		5	1	10
			Dark Sandy Shale		1	1	0
			Fire-clay		1	0	0
			Grey Sandy Shale and Sandstone bands ..		2	2	0
			Fire-clay		2	0	0
			Grey Sandstone		1	2	7
			Dark Shale and Ironstone		2	1	0
			Black Shale		0	1	6
			Grey Sandy Shale		3	1	2
			Grey Sandstone		2	1	10
			Fire-clay		6	2	0
			Black and Grey Shale..		0	0	10
799	0	2	Swinton Pottery Coal..	Coal .. 2 ft. 9 in. Fire-clay 0 ft. 3 in. Coal .. 0 ft. 9 in.	1	0	9
			Fire-clay		0	1	4
			Grey Sandstone		23	1	9
			Black Shale		0	1	8
824	0	2	Coal		0	1	3
			Fire-clay		3	2	7
			Light Grey Shaly Sandstone		2	1	0
			Dark Grey Shaly Sandstone		2	2	0
			Fire-clay and Ironstone nodules		1	1	9
			Black Shale and Ironstone		10	0	5
			Fire-clay		0	2	0
			Grey Sandstone	WOOLLEY EDGE ROCK.	3	2	7
			Blue Sandy Shale	WOOLLEY EDGE ROCK.	0	2	0
			Dark Sandy Shale	WOOLLEY EDGE ROCK.	6	2	8
			Blue Sandy Shale and Sandstone bands ..	WOOLLEY EDGE ROCK.	6	0	0
			Black Shale		1	0	6
864	2	6	Coal	Blue Shale and Ironstone nodules, 2 ft. Coal .. .. 10 in.	0	2	10

Depth from Surface. Yds.	ft.	in.	Name of Strata.	Thickness of Strata. Yds.	ft.	in.
			Fire-clay	1	0	2
			Blue Sandy Shale and Ironstone nodules	2	1	6
			Black Shale and Ironstone nodules	5	0	0
873	2	1	Wathwood Coal	0	0	11
			Fire-clay	0	1	0
			Grey Sandstone	2	0	9
			Dark Sandy Shale	1	1	8
			Dark Sandy Shale and Ironstone nodules	1	0	3
			Shaly Sandstone	0	2	6
			Sandy Shale	1	2	6
			Grey Sandstone	0	2	6
			Blue Shale and Ironstone nodules	3	2	0
			Shaly Sandstone	0	2	0
			Blue Shale	0	1	0
			Blue Shale and Ironstone nodules	2	0	4
889	2	7	Two-foot Coal { Black Shale, 0 ft. 2 in. / Coal .. 0 ft. 10 in. / Fire-clay, 1 ft. 0 in. }	0	2	0
			Blue Shale and Ironstone nodules	7	1	0
			Light Blue Shale and Ironstone nodules	2	1	6
			Blue Shale and Ironstone nodules	1	2	0
			Dark Blue Shale and Ironstone nodules	1	1	3
903	1	0	Abdy or Winter Coal { Black Shale, 0 ft. 8 in. / Coal .. 1 ft. 0 in. }	0	1	8
			Light Blue Shale and Ironstone nodules	6	1	4
			Grey Sandstone	22	1	2
			Blue Shale	0	1	0
933	0	0	Black Shale and Coal	0	1	6
			Blue Sandy Shale	2	1	6
			Grey Shaly Sandstone	2	0	11
			Grey Shaly Sandstone and Ironstone nodules	5	1	0
			Blue Shale and Ironstone bands	5	0	6
			Blue Sandy Shale	0	2	10

Depth from Surface. Yds. ft. in.	Name of Strata.	Thickness of Strata. Yds. ft. in.
949 2 2	Low Beamshaw Coal.. { Fire-clay, 0 ft. 3 in. / Coal .. 1 ft. 0 in. / Blk. Shale, 0 ft. 2 in. }	0 1 5
	Grey Sandstone	1 2 0
	Blue Shaly Sandstone	1 1 8
	Blue Shale and Hard Sandstone bands	9 1 9
962 2 7	Black Shale (Kent's Thin Coal)	0 1 0
	Blue Sandy Shale and Ironstone bands	8 0 0
	Blue Sandy Shale and Hard Sandstone bands.	6 0 6
	Grey Sandstone (Kent's Thick Rock) ..	15 0 0
	Blue Sandy Shale and Hard Sandstone bands.	7 2 6
	Grey Shaly Sandstone	1 0 9
	Black Shale	1 1 5
1004 1 2	Kent'sThick Coal .. { Coal .. .. 0 ft. 4 in. / Black Shale and Coal, 0 ft. 3 in. / Fire-clay . .. .. 1 ft. 2 in. / Coal .. .. 0 ft. 7 in. / Fire-clay.. .. .. 0 ft. 2 in. / Coal .. .. 1 ft. 11 in. / Fire-clay.. .. .. 1 ft. 0 in. }	1 2 5
	Blue Sandy Shale	1 1 0
	Grey Shaly Sandstone	3 1 10
	Blue Shale and Ironstone bands	4 0 4
	Blue Shale	1 0 8
	Blue Sandy Shale	2 0 0
	Grey Sandstone	2 0 0
	Blue Shale	2 1 0
	Blue Shale and Irony bands..	4 2 0
	Blue Sandy Shale	0 1 6
	Grey Sandstone	0 2 6
	Blue Shale and Irony bands	2 0 0
	Grey Sandstone	6 1 8
	Blue Sandy Shale	0 1 9
	Blue Shale and Irony bands..	4 0 0

Depth from Surface. Yds. ft. in.	Name of Strata.			Thickness of Strata. Yds. ft. in.
	Black Shale			1 0 6
	Blue Shale and Irony bands			2 2 2
	Black Shale			0 1 0
1047 1 4	Coal	Coal	1 ft. 0 in.	3 0 3
		Fire-clay	3 ft. 6 in.	
		Coal	4 ft. 1 in.	
		Coal and Dirt,	0 ft. 4 in.	
		Coal	0 ft. 4 in.	
	Soft Fire-clay			0 2 0
	Grey Shaly Sandstone & Ironstone nodules			5 2 9
	Blue Shale and Ironstone bands			5 2 10
	Dark Blue Shale			0 0 8
1061 2 2	Coal			1 1 7
	Sandy Fire-clay			0 0 8

BARNSLEY COAL.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XXVII. SESSION 1900-1901.

The ORDINARY MEETING of the Members was held on Tuesday, December 11th, 1900, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. G. C. GREENWELL, M.Inst.C.E., F.G.S., in the Chair.

The PRESIDENT expressed his grateful sense of the honour which had been done him by appointing him to the office of President—the highest position which the Society could confer on any of its members. He also acknowledged the sympathethic words which were uttered at the previous Meeting by Mr. Joseph Dickinson and others in regard to his father, who was a member of the Society, and President for the years 1867, 1868, and 1885.

PRESENTATIONS TO THE SOCIETY.

Mr. MARK STIRRUP, F.G.S., presented to the Society, on behalf of Miss Morton, of Liverpool, a coloured Geological Map of Liverpool. The gift was intended to commemorate the association which Miss Morton's father had with the Society for many years. Mr. Morton, Mr. Stirrup explained, was an Honorary Member of the Manchester Geological Society, and a Past-President of the Liverpool Geological Society. Shortly before his death Mr. Morton intimated his desire to give his Manchester friends a Geological Map of Liverpool. Mr. Stirrup moved that the thanks of the Society be tendered to Miss Morton for her gift.

Professor W. BOYD DAWKINS, F.G.S., seconded the motion, which was carried unanimously.

Mr. J. B. HARRISON, Government Analyst and Geologist, presented the Society with Reports on the Geology of British Guiana.

A vote of thanks was passed to Mr. Harrison for his gift

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Members of the Society:—

Mr. HENRY CHAMP, c/o Messrs. S. & J. Watts & Co., Portland Street, Manchester.

Mr. HENRY KNIGHT, Manager, Rose Hill Colliery, Bolton.

The following report of the delegate to the meeting of the British Association for the Advancement of Science, at Bradford, in September, 1900, was read by Mr. WILLIAM WATTS, F.G.S.:—

REPORT OF THE DELEGATE TO THE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, AT BRADFORD, SEPTEMBER, 1900.

By Mr. William Watts, F.G.S.

Your Delegate attended both meetings of the Corresponding Societies, in connection with the British Association, held at Bradford, on the 6th and 11th of September, 1900. These meetings were held in the Grammar School, and presided over by Horace T. Brown, Esq., in the absence of Professor Meldola. Three members of the Committee were present, the remainder being engaged in the sectional work of the Association.

Thirty-seven delegates attended, representing local societies in England, Ireland, Scotland, and Wales.

The Committee presented a brief report of the work done by the Corresponding Societies since they were first affiliated in 1883, which will doubtless appear in the yearly volume of the Association.

It does not appear that much good work has been done by the Corresponding Societies since they were attached to the Association sixteen years ago. Conferences have been held yearly and suggestions made of the kind of work to be undertaken, but the Societies do not appear to have entered upon it with that willingness to be expected from so many intelligent representative men in the United Kingdom. The delegates meet and encouraging remarks are made, but nothing is done.

Locally the Corresponding Societies are able to help forward the objects of the British Association, by co-operation in some branch of definite scientific work. Local help is required. Every district has something of

interest common to itself, which men on the spot have the opportunity of witnessing, and which, if intelligently stated, would be sure to find hearers in the sectional meetings of the Association. Human life is too short to see all there is to be seen, on earth and beneath it, so that when rare phenomena come under the observation of a man having the power to see they should not be lost sight of.

The Committee expressed a desire that each delegate should encourage his Society to take up some definite line of work, in any branch of enquiry in which its members are the best fitted. Your delegate hopes that so far as the Manchester Geological Society is concerned, it will endeavour to comply with these wishes, and do what it can to maintain its character and spread its usefulness in the North of England, and honour the men who have worked for it so many years.

Every new discovery renews the pleasure of investigation, and adds joy to life, and satisfies the desire for labour.

Some of the delegates complain that better provision is not made for rooms in which to meet during the Association week for friendly exchanges of opinions relating to the work of the local Societies represented. It was also suggested that a delegate's appointment should hold good for at least two years, and that each Corresponding Society be requested to present an annual report to the Association. By the adoption of this suggestion the delegates would not only get to know each other better but the Association would learn more and more what was being done by the provincial Societies, and would render help where help was required.

By friendly intercourse one learns to unbend more freely. The soul casts away restraint, and mutual help and encouragement are given, scarcely possible on first meeting.

The Committee press upon all the Corresponding Societies to obtain photographs of interesting geological sections above and below ground for presentation to the Association; records of landslips, heavy downfalls of rain and snow, maximum and minimum records of floods, remarkable changes of atmospheric air, the fall of meteorites, and all natural phenomena occurring under the observation of any of the members of the Conferring Societies.

Natural occurrences such as those above enumerated prove valuable when recorded over a wide area of country and submitted for comparison by trained scientists.

The migration, nest building, and the incubating habits of birds were referred to, especially the British songsters and those of beautiful plumage, which are fast becoming rare or extinct, owing to the foolish fashion of ladies wearing feathers as dress ornaments. There is much uncertainty about the habits of birds generally, which extended observation would clear up. It is doubtful whether migration is so persistent and instinctive as imagined, nor are the dates of arrival and departure followed with the unerring instinct one reads of. The Hirundines are not methodical in their flight to and from the localities daily patrolled by your delegate for a period of thirty years. Their movements seem to depend upon the climatic conditions and food supply rather than upon inheritance. Birds can endure much cold if suitable food be obtainable.

Your delegate has seen wagtails flitting about the upper reaches of the Little Don Valley in the depths of winter, when the frozen snow lay deep on the ground.

Thrushes and blackbirds remain during winter where they have been reared if food and shelter can be obtained, and occasionally sing in subdued notes on bright, sunny days.

Information is wanted respecting the habits of insects of all sorts, but more especially of the industrious kinds, such as the honied bee, wasps, ants, spiders, butterflies, and even the common housefly, which can be taught to obey and love. The wasps are great fruit stealers, and it is marvellous how ingeniously they burrow in the dry ground dome-like vaults two feet deep by about twelve inches in diameter in the widest part, and build their combs to fit, without any waste room, tier above tier, each one of which, although built separately, is spiked to the one above.

The number and variety of insects visiting a well-stocked country garden, bright with flowers and ripe with fruit, are numberless.

Their merry sound is kept up all day long in weather bright and warm.

Many retire as evening draws nigh, but others take their places as the shadows fall, and some even pace the peaceful night. All have homes, curiously built of a style of architecture of which Ruskin would not find fault, for the best material and workmanship are provided to meet the varied habits of life.

It must be understood that nothing is unworthy of scientific observation, and that it is the duty of men connected with scientific societies to observe and make their observations known to their race less favoured than themselves.

All are not placed in favourable environment, and all have not equal powers of seeing nature as she is, but the eye can see much when trained by a willing mind.

The second delegate meeting was held on the eleventh of September.

The time was mainly occupied listening to a most interesting lecture by Professor Miall on "Dew Ponds."

He said he had been led to consider the subject in consequence of having seen it referred to in Gilbert White's Natural History of Selborne.

Dew ponds in the main are confined to the chalk downs of England, and are described as naturally-formed irregular drinking places for cattle. They have no visible inlet or outlet for the water, and they maintain a surface film, said to be proof against the evaporating rays of the sun. They differ in some respects from the meres of Derbyshire and Cheshire, but it did not transpire in what essential respect, except that they are fed with dew only, and must exist in the chalk gravels on gently-inclining land where it is presumed the morning dewdrops can flow into them, and far removed from the influence of natural springs or murmuring brooklets.

Sometimes dew ponds are artificially made for the convenience of cattle to drink, in fields where there is no natural water supply. In such cases, tradition relates that rainfall will not fill them, and that before they can be made to hold water, snow must melt in the receptacle. After the crystal snow flakes have been dissolved, henceforth the pool becomes an impervious dew pond, and never dries up.

The depth is restricted to three or four feet, and the clayey matrix, of which the sides are lined, must contain a percentage of lime, or it will not be impervious to dew water.

It is useless to line them with any other kind of material as the dew would not be retained, so that pools holding spring or rain water will not hold dew.

The story as related by the Professor is too interesting to be lost sight of, and whilst he regards much of what is related as legendary, his enquiries led him to believe there

is some truth in unbelief, and he desired all who could to assist in a wider investigation of the subject, and report progress at future meetings of the delegates.

The annual fall of dew where it has been measured, as best it can be, amounts to about one and a half inches, or seven gallons per square yard per annum.

Such a small supply from dew alone would require a square yard per day to quench the thirst of one cow, allowing seven gallons per day of twenty-four hours, or 365 square yards of pond space for twelve months. A moderately sized herd therefore would certainly require more land than most farmers have available, and looking at the matter in this practical way there are no dew ponds fed with dew alone, large enough to meet the demands made upon them in a droughty summer from a well-stocked farm.

Sir William Turner's opening address reviewed the discoveries made in surgery of recent years, and it was made clear how much the happiness of mankind depends upon the profession, for the alleviation of pain, and in prolonging life.

The advances made in surgery during the present century were referred to, and how much they had ministered to the afflicted.

Professor Sollas' address was essentially technical, and required a trained mind in geological science to follow it. His observations were illustrated by lantern views thrown upon a screen, and the attendance was good, and sustained at the subsequent meetings, giving one the impression that geology in Yorkshire is a popular science.

The Professor dealt with the evolution of some phases of the infant history of the earth, and he remarked that the uniformitarian and catastrophist ideas of the physical features of the earth are being shaken by more modern

notions and experience of the cooling within and the slow surface sculpturing without.

In the youth of the planet the wave theory is said to have exerted a profound influence in forming the shape of the globe and its superficial features. The address is one which requires careful reading, dealing as it does with several critical periods, the action of the tides, formation of mountain ranges, origin of the oceans, duration of stratified rocks, periods of time, climatic conditions, the evolution of the living world, and other subjects too long to deal with in a Delegate's report, but sufficiently interesting to be carefully studied by every thoughtful geologist.

In an ante-room attached to the section, Mr. Arthur D. Ellis exhibited a fine collection of atlases, illustrating geography of the 16th, 17th, and 18th centuries. The dates of the surveys range from 1585 to 1758, and found printers at Antwerp, Amsterdam, Oxford, and London.

Referring to Pinkerton's atlas of 1815, the following quaint remarks begin the preface :—"Geography is a study "so universally instructive and pleasing that it has for "nearly a century been taught, even to females, whose "pursuits are foreign from serious researches. In the trivial "conversations of the social circle, in the daily avidity of "the occurrences of the times, pregnant indeed above all "others with rapid and important changes, that affect the "very existence of states and empires, Geography has "become an habitual resource to the elegant female, as well "as the profound philosopher."

Many geological sections, rock specimens, models, microscopical slides, geological and antiquarian photographs were on view, all of which were well worth seeing, and made the temporary museum interesting.

Sir A. Binnie's address in the Mechanical Section was very popular and deeply interesting, being an exhaustive review of the advance of science during the last century. This address was illustrated with a chart, a copy of which I have much pleasure in presenting to the Society for reference by those members who wish to examine it. It explains more clearly than I can the gist of Sir A. Binnie's address, which was listened to with deep interest, flowing as the words did from a scientific as well as a literary mind. It will be noticed that the chart deals with Historical, Biographical, and Statistical matters, easily understood in the illustrated form presented.

Your delegate was able to attend only the Geological and Mechanical Sections of the Association, but he has to report that on the whole the meetings were equal in matter to the average, but there was a slight falling off in numbers attending, which was probably owing to the South African War and the Paris Exhibition.

Your delegate thanks the President and Council of the Society for having appointed him to represent them at the Bradford meeting of the British Association for the Advancement of Science, and expresses a hope that his report will be acceptable to the general body of the members, and will stimulate them to renew their researches in scientific work for the good of themselves and the Society they represent.

On the motion of Mr. G. C. GREENWELL, seconded by Mr. JOSEPH DICKINSON, the thanks of the Society were tendered to Mr. Watts for his services.

Mr. C. E. DE RANCE, F.G.S., read the following paper "On Sulphur and Pyrites in relation to Sulphuric Acid and its applications":—

ON SULPHUR AND PYRITES IN RELATION TO SULPHURIC ACID AND ITS APPLICATIONS.

By C. E. de Rance, Assoc.Inst.C.E., M.Inst.M.E., F.G.S.

The first important notice of this acid is in 1796, when the then Lord Dundonald established the first alkali works in Great Britain, at Walker-on-Tyne, treating the brine obtained at the Walker Colliery with sulphuric acid to produce sulphate of soda direct from brine, to avoid paying the tax then levied on salt of no less than £36 per ton. The sulphuric acid was then wholly manufactured from Sicilian sulphur, of which so late as 1863, 2000 tons were shipped to the Tyne, but acid making from pyrites shipped from Ireland and Cornwall dates from 1840, while Spanish pyrites was first introduced in 1856, Belgian in 1858, and Westphalian and Norwegian in 1861; the annual consumption from Spain and Portugal in 1863 being 72,800 tons, and at present considerably more than 100,000 tons.

The presence of arsenic in pyrites sulphur was early known; it varies in degree from a trace in ordinary pyrites before treatment, up to 45 per cent. in arsenical iron pyrites, or "mispickel," and 14 per cent. in arsenical copper pyrites, and its existence is referred to in pyrites sulphuric acid in Galloway's "Manual of Qualitative Analysis," London, 1850, who states it "frequently contains both arsenic and lead," and in Slater's "Manual of Dye Wares," London, 1870, occurs the important statement: "Arsenious acid is frequently found in samples of sulphuric acid made from iron and copper pyrites. In many cases this substance, being capable of acting as a reducing agent, may produce injury. Acid prepared from Sicilian sulphur should, therefore, be used in dye, print, and colour works, to the *exclusion* of that obtained from pyrites."

Sicilian sulphur only contains earthy impurities, which is got rid of locally by heating the substance in earthen pots placed around a furnace, and the sulphur distils into the form of vapour, which is condensed into other pots outside the others and placed at a lower level. It is again distilled in this country, and its vapours quickly cooled below its melting point, when, as pointed out by Sir Henry Roscoe, it solidifies into "a fine crystalline powder called flowers of sulphur," exactly as aqueous vapour when cooled down below the freezing point of water deposits as snow." When melted at a low heat it can be cast into "brimstone sticks" and "roll sulphur."

The process of sulphuric acid making is well described by Roscoe, who points that *arsenic* may be present from pyrites, and *lead*, from the leaden chambers in which it is prepared, it follows that the latter impurity would be liable to be present, whether the acid came from burning pure sulphur in a current of air, or roasting pyrites, and that lead poisoning may take place in either case.

Previous to the Revolution of 1789, the only soda used in France was obtained from marine plants imported from Spain and Portugal. And all the potash, that can be used in case of need, in the manufacture of glass and soap, was required for the manufacture of gunpowder for the wars then ravaging Europe.

The French chemist, Leblanc, then laid before the "Committee of Public Safety" a scheme for manufacturing soda by adding sulphuric acid to common salt, and converting it into sulphate of soda, and decomposing the latter at a high temperature, 16 cwt. of concentrated sulphuric acid being required to convert a ton of common salt into sulphate of soda.

Up to 1838, all oil of vitrol was made from Sicilian sulphur, but in that year a monopoly was given by the King of

Naples to a French syndicate, and their prices led to the introduction of cheaper sulphur, made from pyrites as a substitute for brimstone; these came from the mines of Wicklow and Cornwall, and were first used in the Tyne industries in 1840, ore from Spain in 1856, Belgium in 1858, Westphalia and Norway 1861, while 72,800 tons was taken from Spain and Portugal in 1863.

About 1853 small quantities of pyrites containing a little copper reached this country from the south of Spain: the supply was limited and transit was on mule back, and the financial result unsatisfactory, and the company which was French, sold their mines to the Tharsis Sulphur and Copper Company, who had already commenced exporting pyrites from Spain, and erected various extensive works in this country for the extraction of copper by a wet process on the residue left in the kilns of the sulphuric acid manufacturers, after the oxidation of the iron and the removal of the associated sulphur. These mines are situated in the province of Huelva, occupying the south-western corner of Spain on the Portuguese side of the Straits of Gibraltar. They were followed by the Buitron Company, and by the Rio Tinto Company in 1873, whose extensive workings are named after the town of Rio Tinto, 52 miles north of the port of Huelva, on the Spanish Atlantic coast, and extend from Aznalcollar, near Seville, in the east, to the celebrated mines of San Domingos, on the Portuguese side of the boundary, a distance of 52 miles. The latter mines were opened up by Mr. James Mason in 1859, and connected with the River Guardiana, near the town of Pomaron; the ore is remarkable for the small amount of matrix and its freedom from arsenic.

The lodes range about magnetic east and west, and occur in Silurian clay slate, traversed by dykes of diabase and quartz porphyry, the last often forming the foot-wall of the lode. They consist of "cupreous pyrites," strings of copper

pyrites, and occasionally of black sulphide of copper, traverse the iron pyrites, and there are also sometimes present galena, blende, tetrahidrite (arsenical copper), and mispickel (arsenical iron pyrites).

The district was very extensively worked by the Romans, a bronze plate now in the Madrid School of Mines states the level, in which it was found, at Rio Tinto was begun in the reign of Cocceius Nerva, A.D. 96-98; the lodes were worked down to a depth of 50 fathoms from the surface by circular shafts of 30 inches diameter, communicating with tortuous galleries, following the best ore; these are still in good condition, through timbers supporting the roof having become saturated with water holding copper in solution, the woody fibre having reduced the sulphates and left metallic copper in the tissues.

In addition to adits, the Romans used various mechanical means for lifting the water from the deep workings. Wheels constructed wholly of wood were found at San Domingos, ten being 16 feet diameter, and two being 12 feet 6 inches; these constructed like a water-wheel with reversed buckets, only that the internal and external are complete throughout, and water once taken up can only escape in the side openings into troughs; each wheel being placed above the other, all turned at the same time, water was easily raised from considerable depths. The work seems to have been carried out by slave labour, human skeletons laden with chains occur in galleries; the calcic phosphate of the bones acted on by the copper salts, presenting the appearance of turquoise; vessels of copper and bronze and earthenware lamps occur of Roman workmanship. But still older stone implements of prehistoric age occur; hæmatite linings of the lodes having yielded colouring matter to form a red pigment, obtained by the action of a "small muller" of coarse porphyry, which was found alongside two rows of regularily arranged

depressions, about 2 inches across, in a slab of hæmatite 9 inches square and 3 inches thick. In some mines near Seville the Romans had lifted water by archimedian screws, from tier to tier of wooden tanks, lined with sheet lead, fastened by oak pegs, showing the Romans recognized the danger of iron.

The Greek name "pyrites" was given (purites), according to Pliney, because "there was much *fire* in it." Heaps of pyrites undergoing decomposition by the action of the atmosphere, and developing great heat; an instance of this is narrated in Hutchin's Dorset County District, as occurring in the Lias Cliffs, between Charmouth and Bridport, which burnt with great smoke. It occurs in almost all geological formations, and in England, is known under various names, "sulphur ores" as a whole; "mundic," in Cornwall, Devon, and Dorset; "sulphur," in Anglesea and the County Wicklow; "coal brasses," in the coalfields of Durham, Northumberland, Lancashire, Yorkshire, Shropshire, and Staffordshire.

In 1873 the pyrites production of the British Isles was 59,000 tons, and the imports into the Tyne 146,500 tons, into the Mersey, 198,000 tons; or 520,000 tons, chiefly from Spain, Portugal, and Norway. In 1876 the quantities were somewhat less; in the latter year out of 8 million tons produced in Cornwall, and nearly 6 million tons in Devon, derived from thirty-three mines, twelve yielded arsenical ores. In that year more than 4,000 tons of crude arsenic was raised from twenty-seven mines in Cornwall and Devon, of an estimated value of nearly £30,000, used chiefly for the manufacture of white arsenic (arsenious acid) by heating the sulphur from the marcasite passing away into the chimney of the furnace when heated. It is exported to Russia for treating furs, and used in manufacturing emerald green.

The danger of the presence of arsenic in sulphuric acid was, as already stated, pointed out to the commercial world in 1850, and it is a remarkable fact that so late as 1885 the "British Pharmacopœia" make no reference to the danger, simply saying, "an acid produced by the combustion of sulphur." But in the 1898 edition, sulphuric acid is described as "an acid produced by the combustion of sulphur, or pyrites," and further adds it should yield no characteristic reaction for lead, copper, arsenic, or nitrate acid.

The same words are used in the "Companion" to the later edition of the British Pharmacopœia, by Peter Squire, 17th edition, revised by P. W. Squire, F.C.S., London, Churchill, 1899, and in the "Materia Medica," by W. Hale White, M.D., 4th edition, Churchill, 1899.

Saccharine bodies, as classified by Roscoe in 1869, belong to three classes: (1) *Sucroses*, or cane sugars $C_{12}H_{22}O_{11}$ chiefly refined in England, by boiling and reboiling with lime, filtering, and decolorizing by animal charcoal; (2) *glucoses*, $C_6H_{12}O_6$, or grape and other fruit sugars which can be artificially prepared by boiling starch with dilute sulphuric acid, forming *dextrose*, or right handed glucose, grape or starch sugar; and *levulose*, or left handed glucose, or fruit sugar, these bodies having the physical property of turning the plane of polarized light respectively right and left.

Commercially there are two kinds of glucose—"chip" and "liquid," the latter is chiefly imported from America, and is used in making jams, confectionery, so-called golden syrup and aerated waters. A well-known American brand of the former, according to Dr. Brown Viet, contained no less than one grain of arsenious acid in 60,000, far more than he has detected in the brewing glucoses.

Mr. Estcourt appears to have been the first to detect arsenic in malt; this apparently may come in two ways:

(1) Liebig's discovery of treating bones for manure with sulphuric acid, one-half of the proportion being usual, though varied according to the strength of the acid; first agriculturally applied by Mr. Fleming in 1841, six bushels of bones dissolved in the acid do the work of 16 bushels before Liebig's discovery. (2) From "brasses" in malting coal and gas coke.

Mr. W. Thompson, in a report to the Committee of the Manchester and Salford Sanitary Committee, that the quantity of arsenic present in hops is very minute, and in malt from nil to 1-33 part of a grain, due to arsenic in the coal used in the kilns. He discovered ordinary kitchen chimney soot yielding $1\frac{1}{2}$ grain of arsenic trioxide per pound.

The medical profession appear willing to pass a beer containing 1-100th of a grain per gallon; many recently (1900) analysed have contained 1-33rd of a grain per gallon. In following this up to its legitimate conclusions, it would appear that pure beer (*sic*) manufactured from malt and hops may contain arsenic derived from pyrites, as well as those produced from sugar, and that "the light ales" now in vogue can only be produced by the latter; English barley not being suitable, and foreign barley malt may be tainted by "brassy coals" with arsenic.

NOTE.—June, 1901.—At Congleton, on the evidence of Mr. Carter Bell, fines were made for selling beer containing 1-40th of a grain of arsenic per gallon; at Liverpool, Dr. Campbell Brown stated that the 1-100th of a grain is not material, but a fine followed in a case of 1-60th.—C. E. R.

On the motion of the PRESIDENT, a vote of thanks was passed to Mr. de Rance for his communication.

Mr. J. BARNES, F.G.S., read the following paper on "The origin of the Pebbles in the Limestone conglomerate occurring near Windy Knoll," illustrated by lantern slides, specially prepared:—

ON THE ORIGIN OF THE PEBBLES OCCURRING IN A CONGLOMERATE FOUND IN THE CARBONIFEROUS LIMESTONE NEAR WINDY KNOLL, CASTLETON.

By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

A paper was read at a meeting of this Society in June, 1897, on a peculiar kind of rock found near Windy Knoll;* this rock consists of a limestone matrix of broken shell fragments and pieces of coral, together with beautifully well-formed oolitic spheroids, while interspersed throughout this matrix are numerous well rolled and rounded flat pebbles of a rock which is darker in colour than the surrounding mass of material. At first the presence and nature of these pebbles in the limestone was somewhat of a curiosity, however, by suitable tests it was ascertained that the pebbles themselves consisted of carbonate of lime.

Perhaps a brief *résumé* of the various suggestions that have been made from time to time as to the nature and origin of these pebbles will not be out of place here. After it was settled that the pebbles consisted of carbonate of lime or limestone, the question naturally arose, of what geological age was this limestone? Was it Silurian, Devonian, or Carboniferous? for at that time none of the pebbles had shewn any signs of containing any characteristic fossils belonging specially to the three great geological periods just mentioned.

One of the suggestions that was made concerning their origin was, that they might be, and possibly were, masses of a semi-plastic calcareous mud, torn up from another and deeper part of the sea floor, and carried by currents into the shallower water in which the conglomerate was formed, but, a very superficial examination of specimens of the rock, pebbles, and microscopic sections soon showed that such

*See *Trans. Man. Geol. Soc.*, Part VII., Vol. XXV., page 181.

could not have been the case, for if this had been their nature and origin, we should have expected finding some of the broken shell fragments of which the matrix is mainly made up penetrating the formerly semi-plastic mud, but this we never do, on the contrary, we find the pebbles always give their impression to the matrix, and never the matrix to the pebbles, and moreover, there is always a layer of fine calcareous matter lying between the pebbles and the matrix, such as is seen surrounding the smaller grains, or oolitic spheroids.

Another idea was, that the pebbles might be some portion of the older and previously hardened parts of the Carboniferous Limestone, that had been blown up from below by one of the many volcanic outbursts of that age, but this hypothesis did not receive any support from the chemical composition of the entire rock itself, inasmuch as no volcanic rock or ash is ever present in the conglomerate, which would have been the case, had volcanic action been responsible for their presence. This idea was then abandoned. After having lain aside for some time, the question was again taken up with a view to discovering the geological age to which the pebbles belonged, and in the absence of fossils visible to the naked eye, a microscopical examination of thin sections was made, with the result that many of those small and lowly forms of animal life known as foraminifera were found to be present, (in fact, quite two-thirds of the entire number known from the Mountain Limestone*) and, as these were identical with the particular forms found in the Carboniferous Limestone proper, the question was clearly settled, that they belonged to Carboniferous Limestone times.

Now, although the question of the geological age of the pebbles had been definitely settled, that of their origin or source still remained to be dealt with; and it is the purpose

* See *Trans. Man. Geol. Soc.*, Part XVI., Vol. XXVI., page 472.

and object of the present paper to show how and why these pebbles came to occupy their present position in the conglomerate, and the solution of the matter has arisen from a number of examinations of the Mountain Limestone which have been made in other parts of the Derbyshire outcrop. After the discovery in the pebbles of so many true Carboniferous Limestone foraminifera, it was considered very desirable that a thorough and careful search should be made, with a view to a better knowledge of these low forms of life, as found in the limestone; one of the objects being to know something as to their mode of occurrence in the various beds; and another was to try and find out a zone or zones, such as those from which the pebbles at Windy Knoll had been derived, for it may be said that at the commencement of the past summer nothing whatever was known to us as to the existence of such a zone or bed at or near Windy Knoll. The foraminifera appear to have existed from the very earliest geological times, down through the Carboniferous Limestone period on to the present day. They are said to be great rock builders, and what they lack in size they make up in numbers. Some parts of the Carboniferous Limestone are in a great measure made up of these small creatures, and they exist as fossils in a most beautiful state of preservation. It is, however, quite incorrect to say that these little creatures are to be found in abundance, or even at all, in each of the beds, for they are not.

A section of much interest is to be found in a quarry on the road from Rowsley to the pretty village of Alport. Going about a mile and a quarter on the main road from Rowsley to Bakewell, and turning to the left, walking on by the edge of a plantation, where the vegetation is very rich, some very fine coniferæ are to be seen. A short distance further on we come to this section, which is merely an ordinary section in the limestone. You might ask, why

this particular one? The answer is, because it is the first quarry or section that revealed to us an abundance of forminifera and a similar rock to that of the pebbles found in the conglomerate at Windy Knoll.

We will examine the section in detail, starting from the lower beds and working upwards. To the ordinary fossil collector this quarry and its contained beds of rock would be a sore disappointment. There is nothing in the shape of a well preserved fossil to be found,—no brachiopoda, cephalopoda, lamellibranchiata, or gasteropoda,—in a word, he would go away with a feeling of disgust, and say that the beds were entirely barren, and that it was useless to look for anything good. There are, however, to be found here some beautiful objects in the way of micro-palæontological remains.

Starting from the lowest point exposed in the quarry some thick massive beds are to be found, which extend upwards; this rock is very highly crystallized, and is of a darkish grey colour, apparently it is unfossiliferous, only a few broken shell-fragments being visible. If however a newly broken surface be examined with a powerful lens numerous well-preserved small gasteropod-like shells are to be seen, which are exactly like those found in the pebbles, comprising many Endothyra and Textularia, which are the most common forms of foraminifera in this rock.

The rock also shews, in section, much crystallized carbonate of lime, in the form of calcite. This massive limestone has also a most characteristic fashion of fracture when hit with a hammer, it has what is known as a flaky fracture, that is, it chips off in flakes, and this is an important point to be remembered, and one to which attention will be recalled several times. Now, the beds lying immediately above the massive bed, shews them to be in thin bands, and intercalated with chert, not thick, as the limestone beneath, whilst in colour they are black, not at all like the massive underlying limestone.

Their microscopical characters differ also very materially, in the first place the number of foraminifera is much smaller, there are some, it is true, as also some fragments of encrinites and shells. Now the fracture of this limestone is altogether different to the lighter and underlying massive limestone, inasmuch as it is conchoidal, *i.e.*, it breaks off with a shell-like fracture, which is very unlike the fracture of the other underlying bed. A typical example of these black beds is to be found at Ashford-in-the-water, where again they are intercalated with chert.

A section of this Ashford limestone shews it to be of a homogenous, non-crystalline mass, quite destitute of life-remains. Now what do the appearances of these various rocks teach us? Do they support the idea, so commonly believed, and so deeply rooted, that limestones are entirely made up of the hard parts of animals that inhabited the sea during the time that the limestone was being laid down? We think not. Some people say that although no life remains are now visible, they were once present, but have since been removed by solution and recrystallization, the section of the Ashford limestone is a flat contradiction to that assertion, since no fossil remains are present, and it is non-crystalline, whilst the most highly crystalline limestone, as is shown in the thick massive portion, contains the best preserved foraminifera. A section of the chert shows very little in the way of life remains, sometimes an occasional foraminifera, sometimes encrinital plates and stems, and more commonly corals.

It must not for one moment be imagined that all the massive beds are made up of foraminifera like the one first examined, for they are not. There is to be found in one of the massive beds lying underneath the foraminiferal massive limestone, organic remains which are quite different, still microscopic but not foraminiferal; what these organisms are

we do not venture to say, as we believe they are new to science, at least some of them.

On studying a little more closely the question of the deposition of limestone, it will be readily admitted by all, that limestone is largely made up of the hard parts of the animals living in the sea during Carboniferous times, it will also have to be granted that some portion is due to chemical precipitation, and it is such portions as are most easily acted upon by the carbonically acidulated water, that may have given rise to the more crystalline parts of the limestone, whilst those parts that show life remains are not so easily soluble, since they are often coated with a layer of either chitinous or albuminous material, which acts as a protector. Besides the process of direct precipitation from solution of calcium carbonate, there is another mode by which it may be produced, and that is from sulphate of lime. Now, this substance is one of the most common bodies present in the sea-water of to-day, and must have been from the earliest geological periods a very ordinary constituent of sea-water. Where is this body to be found in rocks of Carboniferous Limestone age? It is not found at all. What has then become of it, for it must have existed?

The blackness of limestone is due to the presence of decomposed organic matter, derived most probably from an abundance of plant life of a low type, as well also of animals of low forms, and not possessing any hard parts, either endo or exo-skeletons. After the death of these low forms, decomposition would set in, giving rise to powerful reducing agents, that is, bodies capable of removing oxygen from other substances for which it has less affinity, and sulphate of lime is one of them.

The following equation shows how the change may and does take place:—

(a) $CaSO_4 + C_2 = CaS + 2CO_2$.

(b) $CaS + H_2O + CO_2 = CaCO_3 + H_2S$.

The change takes place in two stages. (1) The carbonaceous reducing agents rob the sulphate of lime of its oxygen, reducing it to the soluble sulphide and producing carbonic dioxide; this then re-acts upon the sulphide of calcium, calcium carbonate being precipitated and sulphuretted hydrogen gas liberated, which in its turn would precipitate as sulphides, metals that might happen to be in solution, such as lead, iron, zinc, silver or antimony, and it is in this way that many of the sulphides occurring in the mineral veins in the Carboniferous Limestone may have been formed. It may be asked why this black limestone is so given to occurring in thin bands, and not assuming, as does the underlying lighter-coloured limestone the massive form? It is for the same reason that they are black, or nearly so, *i.e.*, that they are fissile, there being between each layer a thin band of black shining bituminous matter, that acts exactly in the same manner in producing fissuration as does the mica scales in the splitting up of sandstones. A further question may be asked. Why are there bands of bitumen? Well, these may be explained in three ways. (1) That there may have been a separation from the general magna of a portion of the decomposing organic matter, which thus formed a distinct layer; or (2) the deposition of calcium carbonate may have gone on less slowly, and so the organic matter got ahead of it; or (3) there may have been a temporary but periodical increase in the amount of organic matter, and thus a more rapid deposition of the same.

This organic matter in limestone acts as a most powerful protective agent against the action of weather, and this can be shown in a most conclusive and interesting manner. There happens to be in some of the beds of limestone, bands that are made up of both kinds of limestone, *i.e.*, of dark and light parts. When a mass of this limestone is exposed to the action of the weather, all parts are of course equally

exposed to the action of it, but the lighter and purer portion is much more easily soluble than are the darker portions, the result is, there is produced a very irregular surface, the darker parts standing out in strong relief. This is a most important point to be observed in the selection of limestone for building purposes. Leaving this quarry at Alport, we now go to another one to the south of this place, but still on the eastern side of the outcrop, and that is to a very fine section, to be seen on the road leading from Matlock Bridge to Matlock Bath. Here again is to be noticed the same characteristic set of beds, bearing the same relationship to each other—upper beds of thin black limestone, intercalated with beds of chert and underlying this course, the same massive lighter coloured and highly foraminiferal bed as is seen at the section near Alport, the black limestone here bears the same relation (as regards micro-palæontological remains) to the massive that it does at the quarry near Alport, whilst the massive is again as at the Alport quarry very rich in these remains. There is another section in a quarry near Matlock Bath station and again the same sequence is to be observed, with the same fracture of the black as at Alport and the Matlock Dale quarry, viz., conchoidal and with the same flaky fracture as at the other quarries, of the massive, and with the same richness in foraminiferal remains as at the two other places noticed.

Now these features could be pointed out at other places if at all necessary, and the same properties shown to be very constant but this we do not consider requisite. We will now go back again to the outcrop on the western side starting with a view of the quarry as seen at the entrance to Pin Dale, which is about a mile to the east of Castleton, here again, the same sequence of beds is to be seen, the upper ones thin, with chert bands, the lower ones massive with foraminifera.

Passing on towards Castleton, the upper beds assume a different aspect, and become fossiliferous and contain the usual variety of Mountain Limestone fossils, whilst nearer to Castleton, in a quarry to the right are seen the thin upper black beds. Going still further west and west of the village of Castleton the upper beds again change and consist of a mass of well rolled and waterworn shell fragments, this rock is well shown near the Speedwell Mine, it is also to be seen in a section in a quarry lying to the left, on the road from Castleton to Chapel-en-le-Frith, but here it is not the uppermost bed, but is overlain by 6 to 8 feet of thinly bedded encrinital limestone, further west it forms the dip slope of Tray Cliff Hill, and at the surface those highly fossiliferous beds are found, for which this place is so celebrated, and proceeding still more westerly we arrive again at the spot where the pebbly conglomerate is to be found.

It will have been noticed* how very like, in every respect are the fossil foraminifera contained in the pebbles, to those found in the thick massive beds at Alport, and at Matlock, and so many other places, and from the general resemblance of the rock, one would be inclined to think that they had been derived from a similar bed. Now one of the suggestions made some time ago, was, that the sea-floor must have been hardened and uplifted, and formed a land surface from which the pebbles could have been derived, and to-day there is evidence of a powerful nature to show that such was the case. The fact that the rock of which the pebbles consist is so similar in every respect to the massive is very important, they contain the same fossil micro-organisms, the rock has the same, or nearly the same colour, of course there are slight local variations, and another important point is that all these pebbles with only a few very trifling exceptions possess a

* See Trans. Man. Geol. Soc., Vol. XXVI., Part XVI., Plate I., Figs. 1–6, March, 1900.

shape that indicates that they have been derived from a rock that possesses, like the massive at all the places examined, a flaky fracture. The pebbles are flat, longer than broad, and have their flat sides almost parallel, and do not possess a conchoidal fracture. So much for these interesting coincidences.

Now the question arises, Does there exist in the neighbourhood a bed or beds of rock capable of supplying the material that goes to form the pebbles? and if so, what is its position with relation to the pebble bed? There does exist close by the pebbly beach, and stretching eastward as far almost as Tray Cliff this very same massive and highly foraminiferal bed; but it is not seen in section as in the other places, but forms the uppermost bed, and also the dip slope of the hill.

None of those thin beds with cherty bands are to be seen as at Matlock and Alport; thus you see there is some evidence that whilst at other parts the thin beds were being laid down, the thick massive limestone was at or near Windy Knoll elevated into a land surface, from which the pebbles could be obtained. It may be asked why the limestone might not have been uplifted after the deposition of the thin black bands with cherty layers; for this simple reason, that none of the pebbles are of black limestone, and none of the pebbles are of chert. Another and very powerful reason is that where the beds continue, and there has not been any break in the continuity of the deposition of the limestone, the shales follow in a natural sequence, but in this locality a different arrangement obtains. Here the shales are to be found lying directly upon the thick massive limestone, without the intervention of the usual thin black limestone with chert.

The shales lying thus unconformably, or rather forming an overlap, were last year pointed out to the members of the Geologists' Association when on their visit to Derbyshire.

A doubt was expressed by some of them as to there being an unconformity at all, some even went so far as to say that the shales were not *in situ*, but that they had slipped down from the face of Mam Tor which lies to the north.

An examination of the limestone below ought to show at the point of contact with the shales some evidence of marmorisation if a slip has taken place, but there is none; and again the shales ought also to show at the junction with the limestone some signs of slickensiding, this also is wanting, and they have not the appearance of having been transferred to another position. To account for the appearance of the shales upon the massive limestone at this point, the Geological Survey have mapped this district where the shales join the limestone as being faulted, there is, however, good reason to believe the only fault present is one of the Geological Survey. It is a very interesting speculation, as to what height locally the carboniferous sea-floor rose above the water, and whether it remained a land surface to the completion of the limestone deposit.

From the size of the pebbles found, it would appear that high and bold cliffs did not exist, for if the land exposed had been of a considerable height we should naturally have expected the pebbles to have been, at least some of them, of large size, but none are more than three to four inches long. There is evidence to show that the hardened sea-floor, which had been uplifted did not remain so high as to give rise to pebbles during the completion of the limestone deposit, for the pebble bed is found at a depth of twelve feet below the present surface and is only about one foot in thickness, whilst the beds lying above it are made up of the shell fragments and oolite, as is the matrix of the conglomerate, but the pebbles are wanting, which shows that either the land surface after denudation remained permanent, or sunk a little—probably the latter took place—whilst the

shallow water deposit which formed the conglomerate, oolitic, and fragmental shelly beds, was being laid down to the west of this place, there was being produced those beds that are now so highly fossiliferous, and to the east we had the land surfaces, stretching nearly to Tray Cliff Hill which was then under water, and in such suitable conditions that allowed a large variety and numbers of characteristic forms of Mountain Limestone life to flourish, whilst further east there was another part of the sea-bottom that was uplifted and formed an elevation within the action of tide and wave, as has been shown by the presence of so many rolled shells, and there appears to have been quite a series of undulations such as is seen to-day on the north side of the Castleton valley. It will be seen from the evidence that has been put forward that the presence of the overlap, *i.e.*, the shales lying directly upon the thick massive limestone instead of upon the thin black limestone supports the hypothesis of an upheaval of the sea-floor, whilst the presence of the pebbles derived from this particular bed also leads one to expect the finding of the presence of the unconformity, and in this way one supports the other in a most interesting and conclusive manner.

From micro-sections examined from other places, it would appear that near Windy Knoll was not the only locality that had land surfaces; the same kind of phenomenon existed at Bolt Edge, the rock composing some of the beds at this place, and those in which so many fish remains have been found, consist almost entirely of rolled fragments without the oolitic spheroids.

Regarding the vertical distribution of the foraminifera in the Mountain Limestone of Derbyshire, not a great amount can be said about it at present, as only a small thickness has been examined by us; but something can be said as to their lateral distribution, and this on account of the exposure of

the rock at the Windy Knoll district, the exposure here being in the form of a dip slope, and not, as at the other places, of a vertical section.

Those of you who have quarried in the fossiliferous beds of the Mountain Limestone, will have noticed that the distribution of the fossils is such, as to lead to the conclusion that they lived in colonies, in one place there are to be found mainly the Cephalopoda, in another Brachiopoda, others mainly consisting of Lammellibrachiata.

There is not a general commingling of each kind in one spot, it is exactly the same with the foraminifera.

The most common forms are the Endothyra and Textularia, and they are very often found together, in another place not far away Trochammina is the prevailing form, whilst in others Saccammina. There are instances in which the whole of the limestone is made up of Saccammina Carteri, another locality may show scarcely anything but Valvulina, and from the way in which they are found distributed, it may be safely said that these minute creatures lived and died in colonies.

It has been a general idea that the foraminifera were deep-sea loving animals, whether this be so or not, they certainly lived during Carboniferous Limestone times, in shallow water, and in water at such depths as that in which the corals lived, for they are found in abundance associated with the corals, and probably formed a very important part of their food supply.

On the motion of the PRESIDENT, seconded by Mr. JOSEPH DICKINSON, a vote of thanks was passed to Messrs. Barnes and Holroyd.

WIGAN MEETING.

The ORDINARY MEETING of the Members was held on Friday, January 11th, 1901, at the Mining School, Wigan.

Mr. JOHN GERRARD, H.M.I.M., in the absence of the President, in the Chair.

Mr. J. W. HUTCHINSON read a Paper giving an account of some preliminary experiments with duplicate ventilating fans of the Waddle type, 30 ft. diameter, driven by a temporary engine, recently erected at the Bamfurlong Collieries. After an interesting discussion it was suggested by Mr. Hutchinson that a small committee of the Members should join him in making further tests after the permanent engines had been applied.

The publication of the Paper is postponed until the experiments have been completed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XXVII. SESSION 1900-1901.

The ORDINARY MEETING of the Members was held on Tuesday, February 12th, 1901, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. G. C. GREENWELL, M.Inst.C.E., F.G.S., in the Chair.

THE LATE QUEEN VICTORIA.

The PRESIDENT said: Gentlemen, before we commence the business of the meeting the Council wish a reference to be made to a subject which has been foremost in all our minds during the last few weeks. Since the last meeting of the Society a great blow has fallen upon our country, one which has touched its inhabitants to the very core, and which has roused the sympathies of the whole world. We have lost our beloved Queen Victoria, and we, and all her subjects deeply mourn her loss. We look back to the commencement of her long and brilliant reign, and we trace, step by step, her course through times of joy, trouble, and adversity, and, gentlemen, we feel proud that we have lived during the reign of Queen Victoria. From first to last she retained the love and veneration of her people, to whom she was indeed a mother, and from first to last she guided the affairs of this great nation with a wise and skilful hand. Her Majesty's life has been a glorious record, and her memory will live for ages to

come. The Council ask you, gentlemen, to join them in paying tribute to her memory, and to offer our respectful sympathies with His Majesty King Edward VII., and with all the Royal Family in the great loss they have sustained, and at the same time to humbly tender to His Majesty an expression of our deep loyalty and of dutiful homage, with sincere congratulations on his accession to the throne, and a prayer that he may be long spared to reign over us. The Council have approved an address in the following terms, which they suggest should be sent to the King:—

"To the King's Most Excellent Majesty.

"May it please your Majesty, we, the members of the Manchester Geological Society, which was established in the year of the coronation of our late beloved Queen Victoria, beg to humbly approach your Majesty and to offer you our most sincere sympathy on the very great loss which you, Her Majesty the Queen, and the Royal Family, have sustained in the death of your Royal Mother. From first to last Her Majesty retained the love and veneration of all her subjects, and her sympathy with all high and noble objects specially endeared her to all scientific societies, to one of which we have the honour to belong. Her loss will be deeply felt, and her memory will be a permanent and lasting one. Assuring your Majesty of our deep sympathy, we humbly tender our sincere congratulations on your accession to the throne, and in offering our dutiful homage we earnestly pray that your Majesty may have health and every happiness, and that you may be long spared to reign over us."

On the motion of Mr. J. Dickinson, F.G.S., seconded by Mr. Henry Hall, the meeting adopted the address, and authorised the President to sign it and the Honorary Secretaries to send it to His Majesty the King.

A GEOLOGICAL CURIOSITY.

Mr. JOHN R. RHODES (Prestwich) exhibited for the inspection of members a slab of fossiliferous limestone recently found in the solid rock at Arnside. It was discovered, Mr. Rhodes said, whilst some persons were blasting limestone on the hill side for the foundations of a house. A thin band of tenacious red clay separated two beds of limestone, and embedded in the clay the fossiliferous slab was seen. As he thought the slab, found in such a position, would be of more than usual interest, he had ventured to bring it to the meeting.

Several members expressed their interest in the exhibit, and on the motion of Mr. MARK STIRRUP, F.G.S., seconded by Mr. WILLIAM SAINT, a vote of thanks was passed to Mr. Rhodes.

DEVELOPMENTS IN COAL MINING: ELECTRICITY AS A MOTIVE POWER.

Mr. HENRY HALL drew attention to the way in which electricity was being used for winding, hauling, and coal cutting at Broad Oak colliery, situated near St. Helens. He had been much interested in this colliery where the only motive power was electricity, and thought the Society would be interested in hearing something about it. They did the winding and hauling by electricity, and they intended to get the coal as far as they could by the same agency. The power was obtained from the St. Helens' Tramway system, which came within 150 yards of the colliery. He had examined the pit once or twice, and been up and down it by means of the electric motor, and it seemed to him to work very satisfac-

torily indeed. Moreover the cost seemed to be wonderfully cheap. It was only a small colliery, just opening out, and the winder told him they wound in a full day of 24 hours about 60 tons of coal and about the same quantity of rubbish, and the total cost was between 4s. and 5s. a day for electricity. Now it so happened that there was another colliery close by in precisely the same condition. Both these collieries were about 60 yards deep, and each of them wound just the same quantity of coal. One was worked by steam and the other by electric power.

He went into the cost of the colliery where steam was at work, and found that for the steam the cost was 20s. a day—that was for coal and stoker's wages—whereas at the other colliery the cost was something less than 5s., and that 5s. was calculated at 2d. per unit. Since that time the Liverpool Corporation, he noticed, were undertaking to supply electric power at a cost of 1¼d. per unit, which would reduce the cost to something like 3s. The Liverpool Corporation, it should be noted, had undertaken to do this when prices of coal were very high, so that if they could afford to do it now at 1¼d. per unit, the probability was they would be able to do it even cheaper in the future.

In reply to questions, Mr. HALL said that 15s. or 16s. was put down as the cost of the coal where steam was the motive power, about 28 cwt. being consumed, to which was added 5s. for stoker's wages, and the cost of two boilers. It came very fairly, he thought, to £1. He did not think the work could have been done for less. The voltage of the electricity was about 400, and it seemed to him that the winder manipulated his motor much more readily than the engine man was able to manipulate his steam engine. He believed that this particular colliery was unique in England. There was a case, he thought, in Yorkshire, where they

wound coal up a staple pit by electricity, but no other case where it was used for winding men and coal to the surface. The colliery was the Broad Oak Colliery, near St. Helens.

Mr. J. DICKINSON: A very old colliery.

Mr. HALL: Yes, it has been re-opened.

Mr. RHODES pointed out that it was the custom to charge the cost price, or even less, to users of electricity for motive power.

Mr. HALL acknowledged this, but suggested that 2d. per unit would more than cover the cost.

Mr. RHODES: So that if this power was made direct it would cost about 10s. as against 5s.?

Mr. HALL: No.

The PRESIDENT: Then do they charge less in that case than the cost of generating electricity at the colliery?

Mr. HALL: I should think not, for this colliery is not the only customer, and their regular charge is 2d. per unit.

Mr. RHODES: The Manchester Corporation charge less for power than for lighting purposes.

Mr. HALL said a gentleman who knew a good deal about these things told him the other day they had established electric works at Widnes, and he believed the cost of producing the electricity to them as manufacturers would be ¼d. per unit, and not any more.

Mr. SAINT: How does the motor operate? Is it reversible?

Mr. HALL: If the man in charge wants to stop when the cage is going down he has to depend on his brake entirely. He can of course reverse the motion.

Replying to the President, Mr. HALL said the motor had been in use at the colliery six or eight months.

Mr. MITTON asked if Mr. Hall could say anything as to the feasibility of using the electric cable in dusty mines. It had always seemed to him that if one got a fall of earth on the cable there was a danger of sparks being emitted, and of a consequent fire or explosion. He knew a colliery where they had a long length of electric cable for coal getting, and there they had rather dusty roads, but he did not know whether anybody had had any experience of falls on cables underground.

Mr. HALL said he had brought the matter forward because it was interesting as being the only instance in which electricity was used for winding at a coal mine.

On the motion of Mr. DICKINSON, seconded by Mr. MITTON, the thanks of the Society were tendered to Mr. Hall for his communication.

Mr. JOSEPH DICKINSON, F.G.S., contributed the following "Notes on Castle Irwell, Pendleton":—

NOTES ON CASTLE IRWELL, PENDLETON, MANCHESTER.

By Mr. Joseph Dickinson, F.G.S.

Castle Irwell, which has long been a picturesque object in the valley of the River Irwell, is now taken down, and the prominent mount on which it stood is being levelled off together with a large area of surrounding land, to form a new race course, instead of the present one that is being taken to extend the ship canal docks.

This new area is almost entirely in Pendleton. It comprises the whole of the first one of the series of peninsulas formed by the river in its very circuitous course through the County Borough of Salford and the City of Manchester, besides land to the south bounded by Cromwell Road and Gerald Road, &c. The length from north to south is nearly one mile; and the breadth at each end of the peninsula from Douglas Bank Bleach Works to Cromwell Bridge, about 700 yards, but only about 300 yards in the middle where the Castle stood.

Originally, the aspect of the land surrounding the mount appeared almost flat. Yet the alterations being made are requiring huge removals. A large plane is being formed, with an elevation at one part from which an uninterrupted view can be had over the whole plane. Scarcely any of the old surface is being left. Some of the cuttings of drift have been so much as about nine feet in depth; whilst the mount, exclusive of the Castle and its towers, is stated by the Engineer at 34·45 feet, the lowering being from 132·75 feet above ordnance datum to 98·30 feet.

Geologically, the whole is at the north-east or downthrow side of Irwell valley great fault, which throws in the new red sandstone; the coalfield being on the other side, sloping underneath the sandstone.

The sandstone is mainly covered with drift, but there are outcrops of it visible at several places in this part of the river course; and it has long shown at the base of the mount under the castle, and at Broughton Cliff. Further up the river for about a mile there is drift, to near Agecroft Bridge, where outcrops of sandstone resume and continue conspicuously beyond.

At the lower outcrops the sandstone is mostly of a light red colour, very friable, and with an occasional pebble. It has numerous false beddings which obscure the general direction of the dip. At some places the dips are to the east, but most are to the west. Those further up the valley, near Agecroft Bridge and beyond, are plainly south. These differences of dip and other indications leave it open to suppose that eastward from Clifton the Irwell great fault becomes divided. The drift consists of silt, loam, sand, and gravel. A few of the boulder stones in the soft parts of it are distinctly scratched, apparently by geological friction.

The most significant geological feature, now plainly visible, is that the mount was a natural rock formation with a covering of drift, and not a mound heaped up for defensive purposes, or an escape for cattle and sheep in time of great floods. Some of the sandstone forming the base may yet be seen unturfed above the original surface level of the surrounding drift; but persons desirous of satisfying their curiosity on this point should not delay in arranging to see it, as it will soon be cleared and turfed over.

Whether attenders at races or not, all persons fond of fresh air will rejoice that, although the castle and mount are gone a park like area yet remains. This is a great boon to the populous vicinity. It may be that among the crowds attending the hippodrome, many observers will see the beautiful scenery, as well as the racing; and some of them with an eye to detail will deferentially notice that the surroundings are graced with numerous conspicious spires, towers, and structures, representing nearly every church persuasion, the established largely predominating.

The PRESIDENT expressed his appreciation of Mr. Dickinson's interesting Paper, and moved that a vote of thanks be given him for it. Mr. SAINT seconded, and the proposal was passed.

Mr. THOMAS ASPINALL, Analytical Chemist, read the following Paper "On the accumulation of solid matter in steam boilers, and how to minimise the troubles caused thereby":—

THE ACCUMULATION OF SOLID MATTER IN STEAM BOILERS, AND HOW TO MINIMISE THE TROUBLES CAUSED THEREBY.

By Mr. Thomas Aspinall.

The amount of solid matter introduced into steam boilers varies with the quality of water used, and the quantity of coal consumed.

It is advisable that all steam users should have every water examined before using it, or it may cause them very much trouble.

I will give you some results of my experiments and observations respecting same.

In 1891, the Clifton and Kersley Coal Company were using a brook water. They had to convey it nearly a mile in pipes, part of the way was through the bed of a river, and they had to buy the supply of water, as well as expend a large amount on pipes to carry it.

This was a nice bright-looking water, but on analysis it was found to be worse than the water they had close at hand, and free from cost.

This sample contained 40 grains of solid matter per gallon, mineral matter 22·5, and 17·5 volatile matter. The mineral matter contained 10·88 $CaSO_4$ and 3·50 $CaCO_3$. This sample was taken November 12th, 1891.

In this case they introduced into each boiler 8·96 lbs. of solids per ton of coal consumed.

The following sample was taken from a source close at hand.

It was conducted from the river down a cutting of about a mile long.

This sample was not clear, but it only contained 21 grains per gallon, consisting of 16·5 grains mineral matter, and 4·7 grains volatile matter.

The lime salts in this case were all sulphates, amounting to 9·43 grains per gallon, and the solids per ton of coal were 4·74 lbs.

I will give you the amount of solid matter introduced in this case in four weeks:—

Total solids in water used	21·2 grains per gallon.
Coal consumed per day per boiler	3·45 tons.
Solids fed per ton of coal	4·74 lbs.
„ „ day	16·35 „
„ „ week	98·10 „
„ „ on filling the boilers	11·20 „
„ in each boiler at end of 1 week	109·30
„ „ „ „ 2 weeks	207·40
„ „ „ „ 3 „	305·50
„ „ „ „ 4 „	403·60

This shows the amount of solid matter that would be in each boiler if allowed to accumulate. Now in this case, one inch of water at the working level measures 90 gallons, so that one inch of water at the end of the first week would contain 2·65lbs. of solid matter.

At the end of the second week, one inch would contain 5lbs., and 3·27 inches would contain 16·35lbs. of solid matter, the exact amount introduced daily with the original feed water.

Now if this quantity, viz., 3·27 inches, be blown off every day, the total solids would remain at 207·4lbs. instead of accumulating to 403·6lbs. in four weeks.

On August 13th, 1891, I received a sample of water from Rumworth Colliery. This sample contained 242·9 grains of solid matter per gallon; mineral matter 200·9 and volatile matter 42· grains.

In this case there was being introduced into each boiler 54·4lbs. of solid matter for every ton of coal consumed, and 34·5lbs. consisted of sodium sulphate, equal to 78·24lbs. Glauber's salt.

I took a sample from one of these boilers, which, on being allowed to cool, the Glauber's salt separated out crystallised.

I do not know what quantity of coal is consumed at this colliery, but assuming that it is three tons per day, the amount of solid matter introduced would be as follows:—

Coal consumed per day	3·0 tons.
Solids fed per ton of coal..	54·4 lbs.
„ „ day..	163·2 „
„ „ week	979·2 „
„ „ on filling the boiler	128·4 „
Solids in boiler at end of 1 week	1107·6 „
„ „ „ 2 weeks.. ..	2086·8 „
„ „ „ 3 „	3066·0 „
„ „ „ 4 „	4045·2 „

If the Glauber's salt was separated out in this case it would amount to 5830lbs.

In January, 1891, I received a sample of water from the Abram Coal Company, Limited. This was a very bad sample, containing 94 grains per gallon, consisting of 76·5 grains mineral matter and 18·0 grains were volatile matter.

This sample also contained 3·5 parts of free acid per 100,000 parts.

The amount of lime salts in this sample was 47·6 grains per gallon, all sulphates, and equal to 50·37 per cent. of the total solids.

The amount of solid matter introduced per ton of coal in this case was 21·16lbs., and free acid 9·96 grains.

In March, 1891, I received another sample from the same firm. This was a different water altogether from the previous sample.

The total solids in this case were 58·4 grains per gallon, lime salts 3·5 grains, and there were present in this case 25·2 grains of sodium carbonate and 17·3 grains sodium chloride.

I was informed that this supply was obtained about a mile away from their place, and since using it they have had no trouble whatever.

The amount of lime salts introduced here only amounts to 0·874 lbs. per ton of coal, so that if five tons of coal per day per boiler were used, the lime salts would only amount to 3·92 lbs. per day, or about 25 lbs. per week, 100 lbs. per month. The amount of sodium carbonate introduced in proportion to the lime salts is 7·2 to 1.

The next case is relating to a series of boilers at a bleach works, Galloway's tubular boilers. The tubes in some of the boilers were nearly choked up, the adherent deposit being from one to two inches in thickness.

River water was used in this instance. This water was taken on June 10th, 1896; it contained 52·5 grains of solid matter per gallon. 42 grains were mineral matter and 10·5 grains were volatile matter. The quantity of coal consumed per day per boiler was 7·5 tons.

The solid matter introduced per ton of coal was 11·76 lbs., made up as follows:—

Lime and Magnesia Salts	6·22 lbs.
Sodium Chloride	1·70 „
Silica, Iron Oxide, and Aluminia	1·43 „
Volatile matter	2·41 „

The accumulation in this case is very high.

Coal consumed per day per boiler	7·5 tons.
Solids fed per ton of coal	11·76 lbs.
„ „ day	88·20 „
„ „ week	539·20 „
„ on filling each boiler	24·75 „
Solids fed in 1 week	563·90 „
„ „ 2 weeks	1103·15 „
„ „ 3 „	1642·35 „
„ „ 4 „	2181·55 „
1 inch of water at end of 1 week =	7·25 lbs.
1 „ „ „ 2 weeks =	26·82 „
3·21 „ „ „ 2 „ =	88·20 „

So that by blowing off 3¼ inches daily the solid matter would accumulate to over 1100 lbs. To keep the solids from accumulating over 560 lbs., it would be necessary to blow off 12½ inches of water daily.

The next case is from Whittaker Bridge Colliery, A. Knowles & Sons, Limited, Radcliffe.

The water used contained 75 grains solids per gallon, 54·8 mineral matter, and 20·2 volatile matter.

The quantity of coal consumed per day, per boiler, was seven tons, and the solids fed per ton of coal were 16·8 lbs.

This water contained 23·12 grains calcium sulphate, 22·7 grains sodium sulphate, and 4·18 grains sodium chloride per gallon, besides 3·7 grains iron oxide. There were some salts sweating through the joints in this case, and crystallising on the outside.

I examined this deposit and found it to consist chiefly of sodium chloride and sulphate.

The accumulation is as follows :—

Total solids in water used ..	75 grains per gallon.
Coal consumed per day per boiler ..	7 tons.
Solids fed per ton of coal	16·8 lbs.
„ „ „ day	117·6 „
„ „ „ week..	705·6 „
„ „ on filling the boiler	39·6 „
„ „ in 1 week	745·2 „
„ „ „ 2 weeks..	1450·8 „
„ „ „ 3 „	2156·4 „
„ „ „ 4 „	2862·0 „

I will now give you an example showing the difference of the constituents in samples taken from the same place at different times.

The samples were taken from Nash's tunnel, at Agecroft Colliery.

The first sample was taken May 15th, 1891, and the second was taken November 9th, 1891. There had been heavy rain before the last sample was taken, and it must have been percolating into this supply from a greater radius, as the latter contained a large quantity of sodium carbonate, while it was entirely absent in the first sample.

The samples contained :—

	Calcium Sulphate. Grains.	Calcium Carbonate. Grains.	Sodium Carbonate. Grains.
First sample ..	19·68 ..	2·60 ..	None.
Second sample ..	11·81 ..	8·40 ..	16·54

The total solids in No. 1 were, 56·5; and No. 2 were, 68·0 grains per gallon.

A case of rapid corrosion came under my notice in December, 1892.

This was at the sinking of the new shafts, belonging to Messrs. A. Knowles & Sons, Limited, at Pendleton. They were using the water raised from the shaft, and it was largely impregnated with iron, in the form of ferrous carbonate. This salt amounted to 5·07 grains per gallon. It is a very corrosive salt, and it was being introduced into the boilers at the rate of 1·135 lbs. per ton of coal consumed, and the amount consumed was seven tons per day per boiler.

This was feeding a very corrosive salt at the rate of 7·945 lbs. per day per boiler, or 47·67 lbs. per week.

The water was perfectly neutral, so the corrosion was not due to free acid.

The accumulation of solids was as follows:—

Total solids in water used ..	60·2	grains per gallon.
Coal consumed per day	7	tons.
Solids fed per ton of coal	13·53	lbs.
„ „ „ day	94·71	„
„ „ „ week	662·97	„
„ „ on filling the boilers.. ..	18·00	„
„ „ in 1 week	580·97	„
„ „ „ 2 weeks..	1243·94	„
„ „ „ 3 „	2006·91	„
„ „ „ 4 „	2669·88	„
1 inch of water at working level at end of .. .. 1 week =	16·64	„
1 inch of water at working level at end of .. .. 2 weeks=	32·57	„

So that 5·7 inches would have to be blown off daily to keep the solids in each boiler below 680 lbs. The amount of iron salt introduced in four weeks would amount to 190·68 lbs.

The scale taken from this boiler was like a yellow iron ore of poor quality; it contained 5·83 per cent. oxide of iron.

If a lime salt had been substituted in place of the iron salt in this case it would have prevented corrosion taking place, but it would still have been a troublesome water.

The next case is the worst I have ever experienced. This was in April, 1893, at Messrs. Knowles & Sons, Limited, Allen's Green Colliery, Radcliffe. The original supply had been exhausted, and they had to resort to the colliery water to generate the steam to work the colliery engines.

The total solids in this sample were 275·5 grains per gallon; mineral matter 239·8 grains, volatile matter 35·7 grains.

The accumulation was as follows:—

Coal consumed per day per boiler ..	5·0	tons.
Solids fed per ton of coal..	61·71	lbs.
„ „ day..	308·55	„
„ „ week	1851·30	„
„ on filling each boiler	151·52	„
Solids in each boiler at end of 1 week..	2002·82	„
„ „ „ 2weeks..	3854·12	„
„ „ „ 3 „ ..	5705·42	„
„ „ „ 4 „ ..	7556·72	„
1 inch of water at working level at end of .. .. 1 week =	49·00	„
1 inch of water at working level at end of .. .. 2 weeks =	94·00	„

There is nothing practicable in this case, only cleaning out every week, and substituting a lime salt in place of the iron salt.

In October, 1890, I came across a peculiar case:—A water containing only 7·78 grains of solid matter per gallon. This

is a splendid quality of water only it contains one hundredth part of a grain of free acid to the gallon.

This water was being used in a new steel Galloway boiler, which was being corroded in a very serious manner, and on being washed out a deposit was noticed having the appearance of Venetian red. I examined this deposit and found that it contained 62·21 per cent. of iron oxide. There was not a particle of scale in this case, as they were only introducing 3 lbs. of solid matter per day.

When this acid was neutralised all troubles ceased.

The accumulation of solids was as follows:—

Coal consumed per day	1·5 tons.
Solids fed per ton of coal	1·98 lbs.
Solids fed per day	3·0 „
„ „ „ week..	18·0 „
„ „ on filling the boiler	4·4 „
„ in boiler at end of 1 week	22·4 „
„ „ „ 2 weeks ..	40·4 „
„ „ „ 3 „	58·4 „
„ „ „ 4 „ ..	76·4 „

So that there was no necessity for blowing off in this case.

If an average quality of water is taken, and we assume that 3 tons of coal per day per boiler is consumed, the conditions best to adopt would be to prevent the solids from accumulating to more than half the maximum, and that will reduce the trouble by fully 75 per cent.

A boiler working under these assumed conditions would introduce 4·48 lbs. per ton of coal, say 13½ lbs. per day, 81 lbs. per week.

The solids here at the end of the second week would be about 170lbs.

This would become the maximum density if 3½ inches of water at the working level were blown off daily. At this density you would not have anything deposited, only the calcium and magnesium carbonates, and these would be in very small quantities; whilst if the solids were allowed to go on accumulating, without blowing off, the solids would rise in the third and fourth weeks from 170lbs. to 350lbs. Hence the greater ratio of deposition in the last two weeks before cleaning.

On the motion of the PRESIDENT, seconded by Mr. SAINT, a vote of thanks was passed to Mr. Aspinall for his paper. In the discussion which followed, Mr. ASPINALL remarked that everything depended on the nature of the constituents in the water. Where the carbonates predominated they were thrown down at once. Where the sulphates predominated a different result was obtained.

Mr. HALL observed that, apart from the question of damage to the boilers by reason of these accumulations, they meant a great waste of fuel.

Mr. RHODES said that $\frac{1}{16}$ inch of sulphate of lime would prevent five per cent. of the heat passing into the water, and so on in geometrical progression.

Mr. MITTON said he was much interested in this subject, and would propose that the paper be open for discussion after it had been printed and they had had an opportunity of reading it. He had been making experiments with a composition called zathanite for dealing with bad water. The water in question was composed as follows:—Total solid matter, 60·11; lime equivalents, 10·4; combined sulphuric acid, 21·83; calcium sulphate, 4·08; calcium carbonate,

15·567; magnesium carbonate, 4·125. Parts per 100,000. He had been comparing the results between boilers using the composition, and those that did not use it, and he found that in a month long strips of scale came off the plates as the result of using the zathanite composition, whereas in the boilers where no composition was used the scale had to be chipped off.

Mr. DICKINSON reminded the meeting that many years ago the late Mr. Peter Spence, proprietor of some chemical works, brought this question before the Society, and told them how he had sucessfully treated very dirty water by always keeping it alkaline. In this way, no matter how dirty the water, he kept his boilers clean.

Mr. RHODES said it was not always the water that contained the largest quantity of salts in solution that was the most disastrous to the boilers by forming scale. He had had the privilege of going into boilers in all parts of the country and examining them specially, and he found that far away in Nottinghamshire, where the scale was formed from magnesia, it was as hard as porcelain and immovable, while in many other districts, where the scale was largely composed of carbonates, it could be moved very easily and with very simple chemical appliances. It struck him, however, that the firing conditions had a great deal more to do with the formation of scale than was generally supposed. When boilers were worked at a pressure of 65lbs. per square inch, the sulphates gave very little trouble, but now when boilers were largely used at pressures of 100lbs. and more, the sulphates of lime were deposited very readily, and unfortunately the sulphates of lime had a peculiar cementing quality, and when they deposited they carried with them any carbonate there was, and formed the whole into a hard block.

Mr. ASPINALL said he was familiar with a great many of the nostrums for the prevention of scale. What the late Mr. Spence said about the water he had to deal with was perfectly true, but it would be perfectly false to apply the same reasoning to another water in another district. The firing conditions and the amount of steam pressure had no doubt a good deal to do with the water, but it was clear that no general rule could be laid down. Differing circumstances called for diversity of treatment.

It was agreed to resume the discussion on the paper at a future meeting.

FOSSILS FROM THE COAL MEASURES OF FRANCE.

Mr. Mark Stirrup, F.G.S., exhibited some specimens of fossil insects and a few plant remains which he had obtained from the Coal Measures of Commentry, in France. He also showed a number of photographs of the open air workings at Commentry. Ten or fifteen years ago, he said, he had the pleasure of making two or three communications to the Society on behalf of his late friend, M. Charles Brongniart, with reference to these carboniferous measures of Commentry, in the centre of France, whence had been obtained these wonderful insect remains, which were a surprise, he might say, to the world at large. At that time he had nothing but photographs to present to the Society, taken from the specimens themselves. Now he had some specimens from the workings. They found in these specimens insects sometimes as faint impressions, and in other cases the animal was simply crushed and quite visible. Among these insects there were some that were very like those existing at the present day. For instance, there was our old friend the cockroach. There were also representatives of the dragon-fly family. Some people did not believe insects were living at the time of the vegetation of the period represented by the fossils, but against that idea they had to put the fact that something like two thousand specimens had been got from this small quarry at Commentry. Of these specimens about one thousand belonged to the cockroach family, which seemed to have been enormously abundant in the carboniferous forests. At his request,

M. Fayol, the director of the mines, had kindly sent a few specimens to the Museum at Owens College, and it was Mr. Stirrup's intention to send the specimens now exhibited to the same place, where, he believed, they would prove of great interest.

A vote of thanks was passed to Mr. Stirrup for his communication, the PRESIDENT moving and Mr. SAINT seconding the proposal.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XXVII. SESSION 1900-1901.

The ORDINARY MEETING of the Members was held on Tuesday, March 12th, 1901, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

The President, Mr. G. C. GREENWELL, M.Inst. C.E., F.G.S., in the Chair.

A FRENCH GEOLOGIST.

Mr. MARK STIRRUP, F.G.S., laid before the Meeting a publication—Album de Microphotographies—he had received from the widow of Dr. Maurice Hovelacque. Dr. Hovelacque, Mr. Stirrup explained, was a young Frenchman, living in Paris, who took a great interest in the fossil flora of the Lower Coal Measures of Lancashire and Yorkshire. Some few years ago, he visited the principal localities where the calcareous nodules are found in which fragments of plants have been preserved. Since that time, and at the instance of Mr. Kilian, Professor of Geology at the University of Grenoble, he had been engaged in working out the structure of the Alpine limestones and the preparation of a large series of microphotos. These microphotographs had been published at the expense of the family of Dr. Hovelacque and Professor

Kilian, and Mr. Stirrup thought it would be interesting to some members of the Society to see them. No conclusions had as yet been drawn from the mass of material that had been worked up by Dr. Hovelacque and Professor Kilian. The deceased doctor was an ardent young man, passionately fond of science, and, happily, in a position to indulge his scientific tastes.

JUBILEE OF THE OWENS COLLEGE.

Mr. STIRRUP reminded the meeting that the Jubilee of the Owens College was being celebrated this year, and that an appeal was being made for funds to remove the debts of the past and to meet the increasing expenditure of the College. The Manchester Geological Society, he pointed out, had an interest in the College, especially in the Museum, whose maintenance had been a great drain on the College funds, and he desired to commend the appeal to all those members who could afford to help the institution. Much was wanted, and not only Manchester people but those dwelling in the towns around which did business with Manchester ought, he thought, to help on this occasion. The amount wanted was sufficiently large to absorb all the contributions that were likely to be offered.

The PRESIDENT joined with Mr. Stirrup in commending the College to the help of the Society.

TERTIARY SHELLS FROM FRANCE.

Mr. STIRRUP exhibited and explained a collection of Tertiary Shells from the Grignon deposit in the Paris basin. During his attendance at the International Congress of Geologists, held in connection with the Paris Exhibition, last year, Mr. Stirrup took part in several excursions to places of interest to the geologist in the vicinity of the French capital and other parts of France, excursions which had been arranged by a committee of French geologists. In the park of Grignon, about two or three miles from Versailles, he obtained this collection of shells. They are of the *Calcaire Grossier* age of the Eocene division of Sir Charles Lyell, who used these fossil shells as a means to discriminate the different beds of the tertiary formation—Eocene, Miocene, and Pliocene, according to the percentage of recent mollusca occurring in them. Deposits similar to those whence these shells were obtained are found in the Isle of Wight and the Hampshire basin. This fact showed to the geologist that at one time the land of France was joined with that of Hampshire.

A vote of thanks was passed to Mr. Stirrup for his contribution, on the motion of the PRESIDENT, seconded by Mr. WILLIAM SAINT.

Mr. WILLIAM PICKSTONE exhibited some samples of coal from South Africa, and read the following paper "On Mining in South Africa":—

ON MINING IN SOUTH AFRICA.

By Mr. William Pickstone.

When I promised the Secretaries to give a paper on mining in the Transvaal I was expecting to have some notes from one of my friends at Vereeniging, who, before the war, was the manager of the collieries belonging to Messrs. Lewis & Marks which are located near that place (partly in Orange Free State and partly in the Transvaal), but owing to the continuation of the war I am still without the promised information.

I was in South Africa for many months in 1898, and passed through the country from Cape Town to Delagoa Bay and back again. It was my good fortune to be a guest of Mr. Sam Marks at his place, Swant's Koppie, a few miles east of Pretoria, for several weeks, and to be by him introduced to prominent members of the Transvaal Government both at his own house and in Pretoria. By these introductions I was enabled to get some knowledge of mining enterprise both in the Transvaal and at Kimberley that were very interesting to me, and which may also be interesting to the Society.

Among the items which came to my knowledge about the Kimberley Diamond Mines and the combine called De Beers, from one who knew all about it (personally I know little about what has been written on the subject), the following are some of the facts. Diamonds having been found in the triangle formed by the Orange and Vaal Rivers in the extreme west of the Free State, there was a rush of the

usual kind of adventurers into that previously almost uninhabited area—sharp Jews among the number. I pass by the actual political facts and the agreement between the Free State and somebody representing Cape Colony and the British Government, by which for £90,000 the Free State relinquished its rights over that angular territory which became and is now a part of the Cape Colony. Claims were at once set up under the laws of the colony, and digging commenced in the Yellow Ground in which the diamonds were found.

This Yellow Ground was an ordinary water-washed deposit that covered the surface of certain areas, and rested as it turned out on an unequal rocky base. The yellow stuff was easily worked by means of water, and the diamonds separated from the mud were taken out of the pan with other stones, and were picked out by experts.

The depth of yellow mud varied very much, and some of the claims were consequently much more productive than others. At first the work was largely in the hands of individual adventurers, some of whom soon sold out to new comers. As the Yellow Ground was bottomed some of the knowing ones sold out, and found afterwards they had made a mistake. For some enterprising fellow said, Well, as the Yellow Ground is done, why not try the rock—blue ground? and see if there are any diamonds in it; surely the bits of white stone did not grow in the mud.

The rock was found to be the mother ground of the diamonds; the enterprises were enlarged, capital rushed in, town and trade grew up—Kimberley—several important companies were formed, competing with each other so that some of them were not too profitable. The knowing ones came to the conclusion that a combine was the best way out of the

difficulty. That combine was arranged in this way. Certain gentlemen (not all of them Jews, by the way) met to discuss the matter, with the result that a very large sum was seen to be necessary to carry the proposed combine through—one of them (an Israelite) suggested that if another of them visited Europe and conferred with a certain well known firm of financiers, a credit might be opened for the amount that might be needed to carry it through.

My informant suggested to the gentleman afterwards elected, "You, Mr. ——, are by all odds the best man to do this thing." The step was taken, and a credit for two millions sterling was made available. The De Beers Co. was formed, and diamonds, from the Cape Colony, in the hands of the company became a practical monopoly, resulting in dividends of about two millions annually going into the pockets of the fortunate combiners.

It must be understood that this profit, which represents about one-half the total value of diamonds produced by the combine, is in part, if not largely, due to the unusual kind of management introduced after the incorporation of the De Beers Company, about which the managers have been subject to a good deal of criticism, including as it does the compound system.

I need hardly remind this meeting that South Africa, especially in the Transvaal and north of it, is a highly mineralised region, or that up to this time, except for gold and coal little has been done in mining. Indeed when the short time is taken into account since which mining began in and beyond the Transvaal, it is wonderful so much has been accomplished.

The first attempt made by the Government of the late South African Republic was in 1881, when certain conces-

sions were made to the Outlander; one was for the exclusive right to establish iron works. It was well known then and is better known now that all the elements—except perhaps labour—to produce iron cheaply is found in the districts around Pretoria, as well as in other districts. It may be best to say that one of the other concessions made at the same time to the same person was for the sole right to make gunpowder, which may explain why an iron works was thought to be desirable. The powder works concession was taken up by certain financiers (German), but the iron making concession was not. In fact, one of my friends to whom this among other concessions of the group granted to the Outlander was offered, said "it was altogether too previous."

The Rand gold was not at that time discovered. Up to this date even no iron ores are converted in the Transvaal, or indeed anywhere so far as I know in South Africa. I may just say here that the gentleman to whom this iron concession was offered in 1881 on my calling his attention to the apparently wonderful iron ore deposits that cropped out in the railway cuttings near to the coalfields owned by his firm, told me that the one object of his future ambition was to start iron works in connection with his collieries.

Diamond mining is not confined to Kimberley, and from the fact of the stones being found in pipes, it is quite possible that such pipes covered as they may be by surface drift may be discovered over wide regions, just as coal may yet be found much nearer Cape Town than the Vaal River; indeed I have within the last few months suggested to friends of mine at the Cape that it is probable even—not simply possible—that if tests were made on a liberal scale within 200 miles of Cape Town under a capable

geologist coal will be found in the region of the great Karoo. I am told in reply that the Government at the Cape have no money at present for such prospecting, and that individual capitalists are not likely to be found until the war is over, and things readjust themselves. At the same time the Cape Government railways before the war obtained their coal from the Vaal coalfields, 1000 miles north of Cape Town, and will no doubt continue to do so until nearer supplies are discovered

Not much had been done in prospecting for minerals in South Africa until the chance discovery of diamonds, but since that happened there had been much done not only in the two Republics but all over the great areas from the Zambesi to the Cape. I remember a remark by one of the wide awake ones when a reference was made to Rhodesia and its chances to become an important gold-producing territory, "Don't you run away with the idea that Mr. R—— is going to have it all his own way in that part of South Africa. I myself spend £600 per annum in prospecting there, and from what I know of its prospects I recommend all my friends who have "Chartered" shares to lock them up and await developments, both political and commercial."

Gold mining at Johannisberg was developed very rapidly in the ten years from 1888 to 1898, but the profitable mines represented only about one-fourth of the whole number known on the Stock Exchange. Many were shut down for want of further capital, but scarcity of native labour made it all but impossible to work any but the best paying ones, and until more labour can be had, either Kaffir or some imported labour, it will not be possible to make much progress in mining in Johannisberg. Coal is found in this spot, in fact it would seem that geologically the coal was there before

the gold bearing rock was spewed up from the depths below, as in some cases it is said to overlap the coal strata.

With more abundant labour, easier conditions of living for both black and white, and a better water supply for the mines, I do not see any difficulty in the gold production on the Rand being doubled within less than ten years—that is to say, a production of 30 to 35 millions instead of 17 to 18 millions sterling.

As regards increased water supply for the Johannisberg mines, arrangements were in progress—(indeed all but completed in 1898)—by which it would have been pumped from the Vaal River at Vereeniging by successive lifts, a total height of 1,500 feet. The Vaal is at that point and for over 30 miles on both banks of it in the control of the owners of a block of coal lands of about 360,000 acres.

The mine owners were the promoters of this great scheme involving a million sterling, and they had secured way-leaves all the way to Johannisberg by the end of July, 1898.

Coal mining on a considerable scale has been developed around Johannisberg, and on the Vaal at Vereeniging, as well as on the eastern line of railway at Belfast, about half way between Pretoria and Delagoa Bay.

On the table are samples of coal, shingle and stone from the Vaal mines, and a sample of oil shale from the Belfast district; this latter seems to me much like "Boghead" cannel, as it burns freely with a bright flame on being put in touch with fire. As no mineral oil has so far been discovered of any value in South Africa, this shale

would seem to offer a good opportunity to produce it by distillation.

Messrs. Lewis & Marks have spent large sums in coal mining on the Vaal, where from one sinking they were drawing from one seam 1000 tons per day. I went into the workings. The coal strata is not tilted at all, the floor is good, roof splendid; the thickness at this opening is 8 feet, but the seam varies from that thickness to 14 feet as has been proved by several sinkings and many borings. The commercial value of the seam is considerably interfered with by the presence of the black shale, of which samples are shown. On the large piece of coal it will be seen that this shale is closely attached to the coal, which, although in this working is only a few inches thick, was found in another sinking only a couple of hundred yards away to have displaced so large a proportion of the coal as to make the sinking worthless. Both these sinkings were on the north side of the river, and about a quarter of a mile or more distant from it. On that side the mine was free of water and required no prop-wood.

Several openings had been made on the south side of the river also, but no coal was being drawn from any of them when I was there.

To show that only rich men or rich companies can hope to do much in this coalfield, as proved up to the time of my visit, I may mention the fact that on the two shafts of one sinking and the equipment of them, although less than 130 yards deep, over £100,000 had been spent, and by reason of its being so heavily watered it was worthless. Here are some particulars of this venture. The river takes a turn, the north side is sound ground, the south side has a deep sand, which is full of water, it is 50 to 60 feet deep. The winding shaft was 18 feet in diameter. Cast-iron rings that

were deemed to be of sufficient strength were first used, but gave way under the pressure; then steel rings were procured, and the shafts finished. The seam here was also 8 feet thick of good coal. Levels were driven to open it up; there was a good deal of water in the coal; the pumping arrangements that were deemed to be necessary were made, but ere the driving had gone very far, having crossed a small fault, such a rush of water came upon them that all the engine power that was in the mine—which was to do all the work—was insufficient to keep the water down. It was in contemplation to order a pair of larger engines to do the work. Another opening not very far from this was getting ready, that was less watered, and boring was going on about half a mile away. In this case a large plot was set out, about 1500 yards by 1600; boreholes were being put down at the corners of the square to prove the ground both for water, for depth and thickness of seam, and to find whether there were any faults within the block. It will be understood that the strata being level the question of faults is easily proved.

I am afraid I shall have tired you, gentlemen, by the imperfect way in which I have dealt with my subject, but when I tell you that this is the very first time that I have read a paper before any company of scientists, you will, I feel sure, excuse my imperfections of both matter and manner; and when I add that it is read on my seventy-ninth birthday, that should be a further reason for my making this appeal to you.

Mr. STIRRUP, in moving a vote of thanks to Mr. Pickstone, said the subject of South Africa and its mines was extremely interesting at the present time when we were spending a lot

of money in South Africa, and wondering how much we should get back from these mines.

Mr. J. DICKINSON seconded the motion, and passed some observations on the nature of the various samples of coal which Mr. Pickstone had submitted.

The resolution was passed, and Mr. Pickstone briefly acknowledged it.

Mr. JOSEPH DICKINSON, F.G.S., contributed the following paper, "Notes on the Geological Survey of Manchester":—

NOTES ON THE GEOLOGICAL SURVEY OF MANCHESTER.

By Mr. Joseph Dickinson, F.G.S.

A few weeks ago I saw an announcement in the newspapers that in a borehole for water at the baths, in High Street, Chorlton-on-Medlock, certain strata had been met with which, on being referred to Professor W. Boyd Dawkins, were pronounced by him to be Ardwick limestone beds. That being so, a large fault, throwing the strata up to the south-west, must run between the two places. It would be valuable information if a section of the borehole were given, with the direction and rate of dip.

It is now a few years ago, in a cutting for the new circular railway, the same limestones were proved a short distance south of Four Oaks (6-inch sheet, No. CXI. Ordnance Map). The dip there, as I noted at the time, was south-west, the level course from which points to Chorlton-on-Medlock where now found in the borehole. The distance between these places is about 1½ miles.

It seems important that a record of these discoveries should be kept for revision of the Geological maps of the district. Those now in use were prepared by Professor Edward Hull, then on the Geological Survey. There seems no doubt that he was indefatigable in obtaining all available information from the colliery plans, boreholes, and outcrops, and that Mr. E. W. Binney and others opened to him their stores of information. But the misfortune was that the sheets had

all to be filled up whether the geology was known or only conjectured under covering drifts. Hence erroneous data at places now requiring revision.

Cuttings for sewers, piping, and other purposes have recently thrown new light upon the geology of Manchester and the vicinity. At our February meeting I brought before this Society an account of the cuttings at Castle Irwell, in Pendleton. With this the Geological map agreed. Since then I have had an opportunity of viewing the cuttings for the new Cemetery east of Agecroft Bridge, where the rock is covered by drift. From these cuttings, and the valuable plan and sections recording them by the Clerk of the Works, this portion of the survey has also been correctly laid down. The covering of drift is now proved to be about 20 feet, the composition being soil, sharp sand, buff gravel, boulder clay, and at places dark gravel, resting on the upper new red sandstone.

In other observations which I made in 1899, on the laying of a new water main from Bolton Road, by what on the map (103) is called Height Lane but is now Claremont Road, and thence by Eccles Old Road to Eccles, the conjectured position of the Permian marls is fully quarter of a mile too far to the north. As marked on the map, the north-east margin is at Claremont House. Whilst as proved by the cutting for the pipe it is at Broom Cottage, opposite the south west or lower entrance to Hope Hall, 200 yards on the Eccles side of Weaste Lane. The upper new red sandstone also as now proved coming in near Gilda Brook, is shown 330 yards too far south. Further developments are now being made by the extension of deep sewers north of Lancaster Road. North of the Permian marls referred to is shown on the map as Coal Measures. Undoubtedly, Coal Measures lie underneath, but they are covered by an immense thickness

of sand, representing apparently the lower new red or Permian sandstone, here about a mile in breadth.

The Clerk of the Works at the new Cemetery told me that he had long been engaged on excavations in various parts about Manchester, and that he kept a record of the ground met with in every such cutting; and that from information thus obtained he knew before the borehole at the baths was made that the limestones were there.

On the proposal of the PRESIDENT, seconded by Mr. SAINT, the thanks of the meeting were heartily tendered to Mr. Dickinson for his communication.

The PRESIDENT said he thought that the members of the Society and everyone who was interested in the geology of the district were indebted to Mr. Dickinson for his careful investigations and for bringing the results of his enquiries before the meeting.

Mr. STIRRUP expressed his agreement with the suggestion that a record ought to be kept of all the faults that were found and the nature of the strata, and pointed out that not infrequently interesting discoveries were made in the great depths to which the foundations of some of the large buildings in Manchester now went.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XXVII. SESSION 1900-1901.

The ORDINARY MEETING of the Members was held on Tuesday, April 9th, 1901, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. W. S. BARRETT, J.P. (in the absence of the President), in the Chair.

NEW MEMBER.

The following gentleman having been duly nominated was balloted for and elected a Member of the Society:—

Mr. W. BALDWIN, Hall Bank, Rochdale.

The following paper on "Prevention of accidents by falls of roof and sides in coal mines," was read by Mr. JOSEPH DICKINSON, F.G.S.

PREVENTION OF ACCIDENTS BY FALLS OF ROOF AND SIDES IN COAL MINES.

A Review, by Mr. JOSEPH DICKINSON, F.G.S.

Many of us are aware of the large number of accidents to persons employed in coal mines from falls of ground, and of the anxious desire of all concerned to lessen the number. A feeling of gratitude therefore arises to the Principal Secretary of State for sending a deputation of four of the Inspectors of Mines to the Courrières Collieries to view certain methods in ordinary use there for preventing such falls, but which are only practised in Great Britain and Ireland for driving through soft ground.

Attention was drawn to the method by the Inspectors in their General Report for 1899, based upon models shown at the Paris Exhibition. That is now followed by a Blue Book, dated 22nd December, 1900, giving an account of the visit and methods of propping, of which the following is a brief review :—

The Courrières collieries are situated near Lens, in the Department of the Pas-de-Calais. They are very large, employing 6,998 persons, of whom 5,794 work below ground. The output of coal in the year 1899 was 1,930,868 tons. There are 13 shafts, which pass through the Cretaceous rocks to the Coal Measures. The coal seams lie flat at some parts, elsewhere they dip at angles from 10° to 60°, and in places are overturned. The total thickness of coal is 140 feet.

The depths of the workings mentioned vary from 300 to 387 yards. The shafts are tubbed 83 to 117 yards through the Cretaceous formation. The average thickness of the seams worked is from 2 ft. 8 in. to 3 ft. 7 in. of coal. The system of working is chiefly by long wall towards the rise, with the face of work in steps or *en échelon*, each face 13 to

17½ yards and 9 to 10 yards apart, with three men in each face, a gob roadway from each face, and a main gob road in the centre. Some of the coal is worked pillar and stall, pillars about 11 yards apart, centre to centre, leaving the pillars nearly 9 yards between.

The view was of the Louise seam, the section being: top coal, 20 in.; hard clunch, 24 in.; bottom coal, 28 in. The coal is worked by pick without blasting, but in ripping roof to make height for the roadways blasting is used. The clunch parting with rubbish from all parts of the mine suffices generally to fill the gob or worked-out part, or at least two-thirds of it.

The support for the workings, in addition to the gobbing, consists of: in the main roadways, masonry, steel, or timber props; in branch roadways, double timbers or couplings 3 ft. 3 in. apart, with lagging 18 in. between overhead, and also at the sides where needed. In cases where the roof is very bad, cross laggings are added between the others.

In the working places wooden bars 10 to 13 feet long are placed under the roof at intervals of 3 ft. 3 in., each bar being supported by props 3 ft. 3 in. from each other; the space between bars having light poles 18 to 20 in. apart from pole to pole, with cross poles between where the roof is bad. Between the foremost wooden bar and the working face, the roof is temporarily supported by iron bars 4 ft. 3 in. long by 1⅜ in. square with the leading end flattened to a chisel edge, three such being supplied to each workman; these are pushed forward nearly to the face. Having advanced these iron bars fully 3 ft. beyond the lintel on which they rest, light temporary props are set close to the face with a light lintel or pole from the top of each prop to the foremost wooden bar; on completion of which the iron bars are withdrawn. Room being made a fresh wooden bar is put in under the foremost ends of the lintel poles, supporting

this wooden bar with the usual props, and the temporary props are taken out. These men thus work under roof supported excepting the spaces 3 ft. by 20 in.

When ripping roof to make height, iron bars with chisel points are pushed forward in advance above the lintel or coupling of the foremost pair of double timbers, the front of the iron bars being kept up firm by a wedge inserted between the back part of the iron bar and the roof, with other adaptations.

In seams comparatively flat and more than 4 ft. in thickness timber is drawn so far as is consistent with safety. In other seams where more than $\frac{2}{3}$ of the total output is got, the general practice is to leave the timber in because it does not pay to take it out.

When timber is drawn it is done by special workmen who are provided with special tools. These include—in addition to a sledge—a tool, with a head 9½ inches long, having a hammer at one end and a sharp point at the other end for sticking into props; a rake with two pointed prongs; and a cutting chisel; each of the three having an iron handle 8 ft. long.

The cost of timber for support, irrespective of the setting, is about 8½d. per ton of coal got, the maximum cost being one shilling.

In the opinion of the mining engineers, what most conduces to safety is—systematic timbering, with the timber inserted as soon as there is room for it, and the use of temporary iron bars to support the roof in advance of the last setting of timber, until there is room for another setting.

The deaths from falls of roof and sides at the Courrières Collieries during the 30 years from 1870 to 1899, averaged 0·29 per 1,000 persons employed below ground, and 0·87 per million tons of coal raised. The improvement was gradual. In the five years ending 1899, the ratios were only 0·126 and 0·348.

In the United Kingdom of Great Britain and Ireland, the average annual ratios for the corresponding five years ending 1899 were 0·776 per 1,000 persons employed, and 2·048 per million tons (mainly coal) wrought.

In the Appendices to the report extracts are given from the Official Regulations. Among these it is required that in seams consisting of several layers, the excavation must be in descending order; and in thick seams, cutting away must begin by the roof; also, that in seams dipping more than 10°, holing upwards is forbidden; and in very steep seams, the holing of a working face on the level course must begin at the upper end of the face, and the coal must be worked away from the upper end towards the lower end.

The reviewer desires to draw special attention to the very favourable results shown by the working of these Courrières coal mines, the average yearly loss of life during the five corresponding years ending 1899 being only one-sixth of that in our home mines.

It is to be noted, however, that these French seams are all of safe thickness, without any of the thick legless seams common in our country, and that the workings have apparently not yet attained the depth at which coal in narrow work begins to crush by the superincumbent weight.

The cost of the timbering is high, inexplicably so according to what is stated, seeing that the gobs are well stowed, and such useful long-handled tools provided for drawing, yet in most of the seams the timber is left undrawn, not on account of safety, but of its not paying to draw. It may be, although unstated, that with so many seams being worked surface subsidence is a consideration, or as the workings are only at a moderate depth underneath the watery Cretaceous rocks through which the shafts are tubbed, it is a possible precaution against inundation.

The use of iron bars in advance of the timbering is described as having been practised since 1870. The reviewer in one of his visits to the continental mines before iron bars were used saw wooden bars used for the same purpose. The report mentions that the process has long been recognised in our country for driving through loose ground, It might have added that the process of driving through soft ground is minutely described in old mining books, such as Williams' Mineral Kingdom and Westgarth Forster, and shown by diagrams in M. Ch. Combes Traité de l'exploitation des mines. Also that the Lancashire special rules under the 1872 Act require holing props to be set so soon as there is room, which is one part of the programme.

The report relates mainly to extending the use of an old recognised mining practice; yet it contains, besides that, some points deserving careful consideration. The whole system would not be applicable to our thick seams as now worked in one face, or by taking the under part first and ripping down the upper parts in coming back; but the system might in some instances be modified by working in separate layers of suitable thickness. It might also be tried in such seams as are of the suitable thickness. On the whole it merits commendation.

The CHAIRMAN: I am sure we are all exceedingly obliged to Mr. Dickinson for his very interesting paper. I am sure that anything that will show a possibility of increasing safety in the mine, and decreasing loss of life, will be of the greatest interest to us. What struck me, as a practical man, is the immense cost of the timber, and I should like to know what class of timber they use at the Courrières collieries.

Mr. DICKINSON: All kinds—a great variety. But here is one of the deputation (Mr. Gerrard). He is more qualified to answer than I am.

The CHAIRMAN: The other thing that struck me as being, I will not say a little unfair, was the comparison between loss of life in one particular colliery and throughout the United Kingdom. I do not think it is exactly fair to take one colliery or district—which may have circumstances in its favour denied to others—and compare it with the whole Kingdom, where the circumstances are so entirely different. I say that with full regard to the recognised desirability of colliery owners and managers doing all they can to reduce loss of life to a minimum, first of all on humanitarian grounds, and, secondly, because it is an expensive business to injure or kill anybody. Apart from their natural desire to avoid loss of life or injury to limb, coal-owners had a special reason for desiring to carry on their mines as free from accidents as possible. I rather think the comparison is not so much against Great Britain as it seems to be by the figures Mr. Dickinson has given us. The greater immunity from accident enjoyed by the Courrières collieries may be due to the special circumstances of the place, and the special timbering may have something to do with it. But however that may be, I feel exceedingly grateful to Mr. Dickinson for the trouble he has taken to put in short and concise form the amount of information contained in the Inspector's report. Mr. Gerrard, one of the deputation, will be able to throw further light on the subject. I am sorry Mr. Mitton has gone, for he also has visited these collieries.

Mr. JAMES TONGE: Before Mr. Gerrard rises, as no doubt he will, to speak on this subject, I should like to move a vote of thanks to Mr. Dickinson, for his valuable paper. I must say I am a little disappointed in that I had intended myself to read a paper on this very subject. He has been before me with his paper, and he is always in advance of many of us. However, I want to say a word or two on this question. All who have studied the statistics of coal mining recently

will have found that the timbering question seems to be now the one requiring most attention, because the safety through timbering, as I think Mr. Dickinson has always shown, has not kept pace with the increased safety from other improvements adopted in mines. I do not think, myself, that Mr. Dickinson has at all given those figures in any way against our country, because he has only given a very short *resumé* of the facts dealt with in the report. I was pleased to learn from the Blue Book that the Inspectors have compared some of the collieries with the Courrières collieries. My figures vary a little from Mr. Dickinson's. He gives the death rate from falls of roof or side at these collieries as 0·12 per thousand persons employed. Now I have it from the Blue Book, if I have not taken it incorrectly, at 0·15. That is more than Mr. Dickinson gives.

Mr. DICKINSON: You have taken the average of the last ten years, and I took the average of the last five years so as to compare it with that of the English mines for the same period.

Mr. TONGE: I thought I had taken the five years, for it is only with the last five years that a comparison could be made. However, that is a matter that may be corrected. It makes a difference in what I was about to say. I was congratulating myself that we had two collieries in this county, where the accidents were less than at the Courrières Collieries—where the average was 0·14 as against 0·15. I have the honour of being connected with one of those collieries in which the average death rate was so low, and I shall not be accused of egotism if I say that my son is the manager. I have been much interested in the story of the Courrières Collieries, and I should like to move that the paper be read again, at a future meeting.

Mr. GERRARD: With notice.

Mr. DICKINSON: It will mean a little more labour to read it again.

Mr. JOHN RIDYARD: I have much pleasure in seconding the vote of thanks to Mr. Dickinson. He has given us a most interesting paper on a subject in which I have taken very great interest. There is no subject more worthy of the attention of colliery owners and managers than this—the prevention of accidents through falls of roof or side.

Mr. DICKINSON: You could describe how you have worked some of the thick seams.

Mr. RIDYARD: One point occurred to me. The mines referred to seem to have thinner seams, and we know from experience there are fewer accidents in thin than in thick seams. Men are inured to the practice of seeing to the roof more carefully in those thin seams than in the thicker ones. I think that is the experience of mining engineers in this country generally.

Mr. JOHN GERRARD: I was waiting to hear what others had to say before venturing to speak myself. This much I will say, I am very grateful to Mr. Dickinson for having brought this subject before the Society, and I sincerely hope that he will assent to Mr. Tonge's request to allow it to come before another meeting with notice, because none of us had the slightest idea that the subject would be brought before the meeting this afternoon, and I must say that it is a subject that will bear consideration and discussion. The more we turn it over the better and the fuller the view we shall have of it, and that is what we desire. I don't want us to miss a single point. It is possible that in describing the collieries, and in trying to explain the mode of working thereat, we may have overlooked something. Therefore, I say, let that something be at once pointed out, and let us have full consideration of all the facts and circumstances of the case. What we do not want is to allow the thing to drop. Therefore I am exceedingly grateful to Mr. Dickinson, who is always to the fore in all these

matters, for having brought this interesting subject up this afternoon. I don't know that I could go into the various points now, certainly I should prefer to choose my words very carefully indeed with regard to them, but if at a subsequent meeting we could have the subject brought forward, and we could induce some of our colliery managers to attend and give us their views, then I should be not only willing but anxious to be present, and to join in a friendly discussion upon this important question. Mr. Barrett has put two points before us. (1) Whether there may not be something in the kind of timber used, and (2) Whether the conditions that prevail at the Courrières collieries are singular or exceptional as compared with our own mines. With regard to the timber used, I think we clearly ascertained that more care is taken at this especial French mine with regard to the timber than is generally taken in this country. The Managing Director assured us that that is a matter which he looks into himself, as to the right kind of wood and as to the time at which it shall be cut, and as to when and how it shall be prepared. Some of the timber must not be used fresh, and other kinds must not be kept. The mere mention of these points shows that the kind of timber used is very carefully considered there; the preparation of it, the taking off of the bark—all these points have their full consideration, and nothing is done in a haphazard sort of way. It is not by chance that this timber or that is taken into these mines. The whole question is carefully considered, and as the result of a long experience, they have selected the best kinds of timber to be used in different parts of the mine, and gained a knowledge of the conditions under which the timber should be prepared. With regard to the conditions of the mines, I think it will be obvious to you, by the mere statement of the number of seams, the number of shafts, the area of the

royalty—I believe it is over twenty square miles—that the conditions are diverse. In an area of 21 square miles, with nine working shafts, with 44 seams of coal, it is obvious there must be some difference in the conditions, and so we found that some of the conditions are extreme, some are moderate, and that on the whole you may sum the matter up by saying that the conditions there are somewhat similar to the conditions that obtain in this country. There is every variety of dip. With regard to that, all I need to say to you is this, that we went into a seam that was absolutely turned over so that the floor of one place formed the roof of the part we were in. That fact indicates variety of dip, from the steep to the flat. It is obvious there must be various conditions with such a large number of seams. Therefore the lower rate of accidents from falls of roof in the French mines is not due to more favourable conditions in France as compared with our own mines. It is due—and this is the main lesson I learnt—to systematic timbering. My opinion as to the value of systematic timbering has been strengthened. In the decade, from 1870 to 1880, the average death rate per thousand persons employed below ground was 0·76. In 1880, they began to enforce the system, with the result that the death rate fell from 0·76 to 0·24 in the succeeding ten years. In the discussions held much has been said as to the iron bars next to the face. That is what the French people tried last. The enforcement of systematic timbering gave the first marked results—a reduction from 0·76 to 0·24—and it was after that reduction had been established in ten years that they found there was still a weak place to be dealt with between the ordinary timbering and the coal face, that they tried these iron bars. Now with regard to the use of iron bars, it is not at all similar to going through soft ground. The iron bar does not enter into the coal, but to my mind it is the application of a very interesting

mechanical principle, that is to say, by the use of an iron bar projecting beyond a fulcrum. The principle is to bear up the roof between the timber next to the coal face. It is not at all a question of going through soft ground. I am very pleased to say two of our coal owners intend to try a modification of this bar; that is to say, to place on the prop a long cap, say three feet in length. The form will depend on the conditions. By placing a cap three feet in length on the top of a prop you get some support between the prop and the coal face. I shall watch the experiment with considerable interest. It is a first step. At any rate we ought not to be content to go on losing the number of lives we do from falls of roof year by year without some attempts to reduce the number.

The resolution of thanks to Mr. Dickinson was passed. In answer to the request to allow the paper to be read at another meeting,

Mr. DICKINSON said: I am very much obliged to you for the vote of thanks, and for the compliment you have paid me by asking me to read the paper again. According to our regulations, any paper that is read and is thought by the Council to be worthy of being printed, is included in our Transactions, so that if this paper should be approved of by the Council it will be printed in the Transactions, along with the very able discussion we have had this afternoon. Then, when it has been before the members, if any one wishes, the discussion might be resumed, but I think a second reading of the paper would be unnecessary.

The CHAIRMAN: Perhaps you will leave yourself in the hands of the Council. Will you do that?

Mr. DICKINSON: I have written the paper for the benefit of the Society, and it is theirs to do with as they think fit.

The following paper "On *Prestwichia rotundata* found at Sparth Bottoms, Rochdale," was read by Mr. W. BALDWIN:—

ON *PRESTWICHIA ROTUNDATA* FOUND AT SPARTH BOTTOMS, ROCHDALE, LANCASHIRE.

By Mr. W. Baldwin.

It is with very great pleasure that one hears of any fresh additions being made to the palæontological knowledge of the district in which one happens to be placed; so that I experienced a pleasing sensation when Mr. H. Maxim, of Rochdale, brought before my notice an exceedingly fine specimen of the fossil crustacean, *Prestwichia rotundata*, which he had met with at Sparth Bottoms, Rochdale, towards the latter end of last year.

A figure of the fossil is shown in the accompanying figure, and is natural size; any imperfect part has been restored, and the telson, although no sign of it is visible, has been inserted.

The following is a description of the specimen, which is slightly smaller than Professor Prestwich's one, and which is described by Dr. Henry Woodward in "A Monograph of the British Fossil Crustacea belonging to the order Merostomata," 1866. I adhere to Dr. Woodward's description as far as possible.

The fossil belongs to the order Merostomata, sub-order Xiphosura, genus *Prestwichia rotundata*.

The body of *Prestwichia rotundata* is divided into three parts which are movably articulated together.

The most anterior is the head shield, which is nearly three times as broad as deep, and is nearly semi-circular in outline. The front margin of the glabella is arched, and

just within the anterior border should be the larval eye spots, and the compound eyes on the lateral border. I say should be, for in the present specimen I have been unable to trace either larval eye spots or compound eyes.

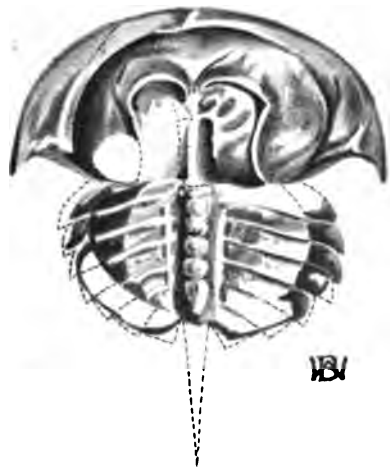
The glabella is divided down the centre for half its length by a raised ridge, which terminates in a blunt spine posteriorly, whilst in front it bifurcates, forming an arched ridge on either side of the mesial line. The two equi-distant ridges, which also spring from the posterior border on each side of the mesial ridge of the glabella, and unite with and complete the arched ridges in front, can just be made out. The same remark also applies to the two lesser arches, which unite the median and the two next lateral ridges half-way up on either hand.

The axis of the thoracic somites is narrow; each somite is ornamented on the median line with a single blunt tubercle, a somewhat larger tubercle marks the coalesced and rudimentary abdominal portion. The broad membranous margin of the thoracico-abdominal somites is divided by seven strongly marked spines of nearly equal length.

The following are the measurements of the specimen:—

	Inches.
Greatest breadth of head-shield	$1\frac{11}{16}$
Greatest length of head-shield	$\frac{7}{8}$
Length of genal spines	$\frac{3}{16}$
Greatest breadth of thoracic somites	$1\frac{1}{16}$
Greatest breadth of axis of thoracic somites	$\frac{3}{16}$
Breadth of thorax at point of union with head-shield..	$\frac{7}{8}$
Length from back of head-shield to point of insertion of telson	$\frac{9}{4}$
From back of head-shield to edge of membranous border of abdomen..	$\frac{7}{8}$

Trans. Man. Geo. Soc. Part VI; Vol. XXVII.
To illustrate Mr. W. Baldwin's Paper.



PRESTWICHIA ROTUNDATA

The restored parts are shewn in dotted lines.

The telson, as in all other specimens hitherto found, is missing.

Locality.—Rochdale is underlain by rocks belonging to the Lower Coal Measure series, but to the south-west, between Rochdale and Heywood, as will be seen on reference to Lancashire Sheet 88, of the Geological Survey, a small portion of the lower beds of the Middle Coal Measures are repeatedly thrown in by several large faults, so as to form two isolated patches, and two promontories jutting out northward from the general range of the Middle Measures. These are shown on the map in a darker tint than the rest. It is almost in the centre of one of these promontories, at a distance of about half-a-mile to the south-west of the Rochdale Town Hall, that certain beds, to be described hereafter, are brought into view in an isolated eminence at Sparth Bottoms, by the excavation in connection with Messrs. Ashworth's brick-making operations.

The rocks dip at about an angle of six degrees, and are formed in a basin-like depression, so that the direction of dip is constantly changing.

At the last mentioned place the following section of rock is exposed:—

Sand and gravel, about four feet thick, underlain by about four feet of stiff blue glacial clay, seen to be thickening to the north-east and also to the south.

Underneath is strong, irregularly bedded shale of a drab colour and containing nodules of ferrous carbonate in beds. Some fine examples of *Sigillaria* with *Stigmarian* roots attached have been found in this stratum. Some of the trees were in an upright position and some inclined. The nodules, which are exceedingly hard, often contain traces of ferns, &c.

The following are some of the specimens met with :—

Calamites in abundance; in passing let me mention that the beautiful specimen figured in "Scott's Fossil Botany," page 35, was met with here.

Sphenopteris trifoliata, *Sphenopteris murcata*, and *Sphenopteris haeminghaussii*.

Alethopteris lonchitica, *Pecopteris dentata*, *Neuropteris accuminata*, *Neuropteris gigantea*, *Asterophyllites*, *Lepidostrobus* in abundance, *Sphenophyllum*, *Cordaites*, *Anthracosia*, and the latest addition to my knowledge is *Prestwichia rotundata*,* which has been described at the beginning of this paper. The bed from which all these were derived is shown in the section† which I have prepared; the position being indicated by a red arrow. The thickness of the bed is about twelve feet. The bed below this is composed of a blue grey shale about twenty feet thick which forms a clay puddle on exposure to the weather.

Fragments of ferns, chiefly *Pecopteris* occur in this stratum, but unlike the one above are not contained in nodules. Next in descending order is a bed of fine grained sandstone, about fifteen feet thick, and below this is seen a similar blue grey shale to that previously described.

Following the dip of the beds in a south-westerly direction for about a quarter of a mile from the last mentioned place, and underlying the new Sparth Mill is the old winding shaft to the Sparth Bottoms Colliery. Here the following strata was run through in sinking the shaft:—

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* A cast of the fossil is deposited at the Manchester Museum and also at the British Museum.

† The section is not figured here.

	Feet.	Inches.
To bottom of Neddy Mine	66	0
Underclay	4	0
Sandstone..	4	6
Black Shale..	12	0
Underclay..	12	0
Coal	0	8
Underclay..	1	0
Coal	0	6
Underclay..	3	10
Sandstone	16	0
Underclay	8	0
Sandstone	15	0
Black Shale	4	0
Coal	0	1½
Underclay..	3	6
Shale, with ironstone bands	3	4
Shale..	9	0
Sandstone or Shale	18	0
Shale..	30	0
Underclay	0	1
Shale..	21	0
Sandstone and Shale	40	6
Shale..	48	6
Black Shale..	4	0
Coal	2	7
Underclay } Royley or Arley Mine..	0	4
Coal	1	6

The bed termed shale with ironstone bands is very probably the same as the one brought to the surface at Sparth Bottoms, and containing the ferruginous nodules; as such I have regarded it.

From the foregoing information, the horizon in which this specimen of *Prestwichia* occurred was below the Neddy

Mine, and probably about 60 yards above the Royley or Arley Mine.

I take it that the presence of *Prestwichia* in this bed may be accounted for if we let it be granted that the bed formed part of the lower end of some great delta, and it was during a period when the sea inundated the lower portion that *Prestwichia* found its way there. This idea is merely suggested, but I do hope that diligent search in the same bed may reveal the presence of more of the same genus, and probably of other forms of marine life.

In conclusion, let me express my gratitude to Professor Boyd Dawkins and to Dr. Woodward, to both of whom I am indebted for much assistance as to the classification of the specimen, and also to others who have given me information regarding the district dealt with in this paper.

The CHAIRMAN: I am sure it is a very great pleasure to this Society that a gentleman so recently elected as Mr. Baldwin should come before us with such a very excellent paper on the interesting subject he has brought before us. It is a little beyond me, but I think, all the same, we are greatly indebted to Mr. Baldwin. I endorse his closing remarks, in which he expressed the hope that this discovery will prove an incentive to geologists to proceed further in the matter, and try to get other objects of interest from the same or neighbouring districts. We may indulge the hope that we shall have some more interesting papers furnishing details on this question. I have great pleasure in moving a vote of thanks to Mr. Baldwin, and I venture to hope we may have more young members who will be as ardent as he has been in preparing for us a paper to which we have listened with so much interest.

Mr. J. DICKINSON: I beg to second the motion and leave Mr. Baldwin to Mr. Holroyd, to enlighten us a little further.

The resolution was carried.

Mr. W. F. HOLROYD: With regard to the specimens, a description of which we have just had given, I may say the *Prestwichia rotundata* is generally regarded as being a very rare kind of fossil, and comparatively few of them are to be found in our museums. I think we cannot do better than give all the encouragement possible to anyone who works upon these ferruginous nodules and the higher kinds of crustacean groups. Two or three years ago a gentleman brought to me two specimens of the *Prestwichia rotundata*, which he had obtained from the Glodwick colliery, near Oldham. One specimen I have here, and the other is in the possession of Mr. Barnes. My specimen shows the tail plate, but in the other one it is not well preserved. On the reverse side there is a small portion of the *Sphenopteris* fern, which corroborates the statement of Mr. Baldwin. I am glad we have had this interesting paper on this subject. It is to people who are not interested in colliery matters a great relief to turn to pure geology. Our Society would not be of interest to myself if we did not occasionally have some purely geological matters brought before our notice. I am very pleased that Mr. Baldwin has brought this matter before us. I am sure it is of very great interest, to some of the members at all events.

Mr. J. DICKINSON: Apparently the specimen which Mr. Holroyd has brought is from the same horizon of ground as Mr. Baldwin's.

The following "Notes on a Fossil found in the Shales of Pule Hill, Marsden, below Millstone Grit," was read by Mr. W. F. HOLROYD:—

NOTES ON A FOSSIL FOUND IN THE SHALES BELOW MILLSTONE GRIT, PULE HILL, MARSDEN.

By J. Barnes, F.G.S., and W. F. Holroyd, F.G.S.

Some two years ago whilst searching amongst the Pule Hill Shales, a fossil of a somewhat interesting character was found. It appeared at first sight to be a portion of a large Orthoceras, but a further and more careful examination leads us to believe that it belongs to the genus known as Cyrtoceras, and probably also to one of the rarest members of that family. De Koninck, in his "Faune de calcaire Carbonifère de la Belgique," has named a similar fossil shell Cyrtoceras cornu-bovis. Perhaps it will be advisable to read his description of this interesting organism.

Cyrtoceras cornu-bovis, L.G. De Koninck, Pl. XXXVI. Fig. I.

Cette espèce constitue la plus volumineuse de toutes ses congénères carbonifères qui me soient connues. Elle a la forme d'un grand cornet faiblement recourbé et largement ouvert à son extrémité antérieure; son extrémité inférieure parait avoir été pointue son accroissement en longeur et en largeur a été rapide. La section transverse de la spire est circulaire. Les cloisons, même les premières, sont assez éloignées les unes des autres et sont toutes à peu près équidistantes; elles sont normales à l'axe et très peu profondes; la distance moyenne qui les sépare les unes des autres est d'environ 8·75 millimétres. Le siphon est large, infudibuliforme situé de côté ventral à une distance de 3 centimétres du bord de l'une des dernières cloisons du spécimen que j'ai sous les yeux. Ce spécimen n'a conserve aucune trace de têt qui cependant parait avoir été *lisse* ou à peu près lisse, une partie de la contra-empreinte n'ayant laissé apercevoir aucun vestige d'ornamentation. La dernière loge ayant complètement disparu, j'en ignore le

forme et la longeur. Dimensions : La longeur de l'unique spécimen connu est de 17 centimètres ; il est composé de vingt loges ; le diamètre de l'extrémité supérieure est de 8 centimètres ; le siphon est situé a 3 centimètres du bord ventral et son diamètre est de 6 millimètres. Il est probable qu'un spécimen complet de cette espece atteindrait une longeur de plus de 25 centimètres.

Rapports et différences. Je ne connais aucune espèce de Cyrtoceras Carbonifère qui atteigne les dimensions de celle-ci surtout en ce qui concerne le diamètre de son extrémité antérieure et qui par conséquent puisse lui être comparée. Certaines espèces dèvoniennes s'en rapprochent, telles sont les. C. lineatum A. Goldfuss et ventricosum. J. Steininger. Le premier en diffère cependant par la forme de sa section transverse qui n'est pas circulaire, et par la situation assez voisine du bord ventral de son siphon, le second par sa forme plus allongée ; et la nombre plus considérable de cloisons pour un même espace.

Gisement et localité. L'unique spécimen connu de cette espèce a été recueilli par le baron de Ryckholt dans le calcaire noir de Bachant. (assise V. a.)

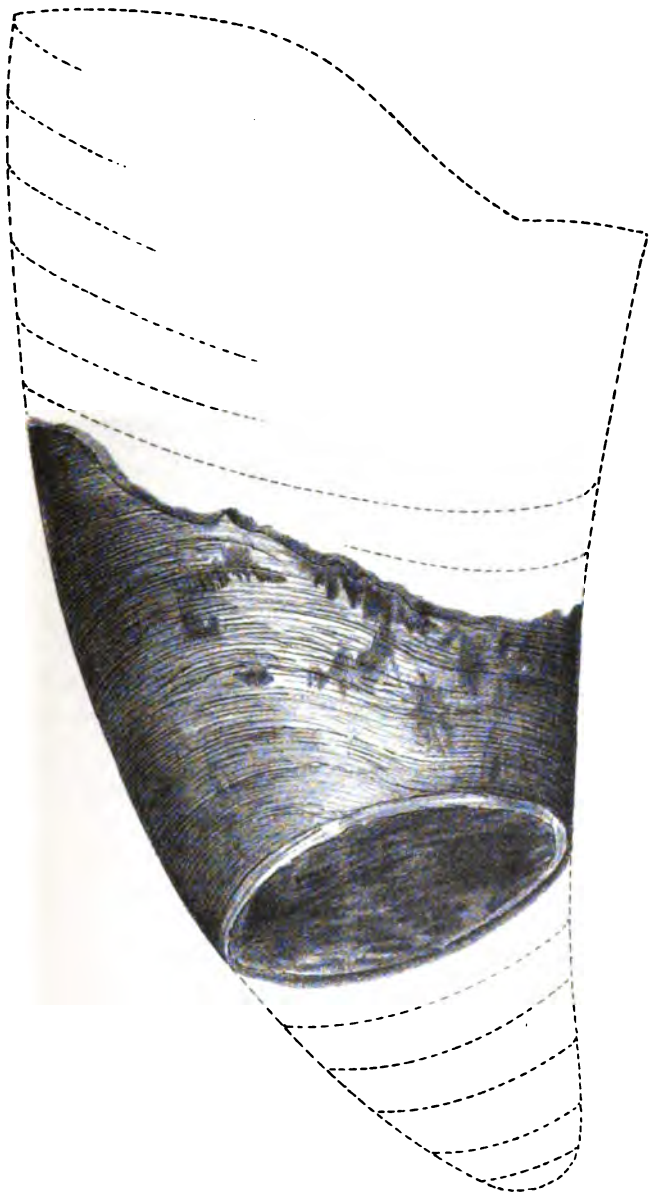
The portion of the fossil Cyrtoceras before us agrees in general characters with De Koninck's description, and to some extent supplements it, inasmuch as it possesses, for five-sixths of its circumference, the test or shell, and shows its ornamentation clearly. It is the only one of the fossils figured by De Koninck in his list which has any resemblance to this specimen. In the British Museum Catalogue of the Cyrtoceratidæ, by Foord, in 1888, there is no mention of this species, although most of the family are there referred to, probably because, as De Koninck says, the specimen is unique. It is quite possible and indeed probable that the species is new, but the fragmentary character of the specimen prevents positive determination.

Most of the members of the family are rare, and the specimens in the British Museum are for the most part single specimens, and also mostly in an imperfect state. No mention is made in any work with which we are acquainted of the fact of this species having been found in Britain, and few museums possess any representatives of the family at all.

Hence the reason for bringing the fragment on the table before the notice of the Society. Before describing the specimen, it will be better to call your attention to the distribution in time and space of the Cyrtoceratidæ. We find Orthoceras and Cyrtoceras in the Tremadoc slates in Wales, and also in the Lingula flags of Canada, while in the Ordovician of that district we have 216 species of Orthoceras and 93 species of Cyrtoceras. In the Bohemian Basin, 261 species of Orthoceras and 328 species of Cyrtoceras are found, while in the Permian (Dyas) of Germany there are only three species of Orthoceras and one species of Cyrtoceras, thus showing the maximum development and extinction of this family. Here, you see, the range of Cyrtoceras is from the Cambrian to the Permian, the greatest number of forms occurring in the Silurian. It is certainly most interesting to find a specimen of this family in beds which lie, as do those at Marsden, between the upper part of the Carboniferous Limestone and the lowest Millstone Grit. The particular description of the fragment found is as follows :—

The substance of the fossil is iron pyrites mostly, and hard black shale.

Its diameter at the smaller end is 46 millimetres, and at the larger, 65 millimetres The distance apart of the chambers shown is eight millimetres, the depth of the concavity of the chamber is quite eight millimetres. The length of it is 50 millimetres, and the thickness of the test, one to three millimetres.



FRAGMENT OF CYRTOCERAS CORNU-BOVIS.

Dotted line shows adult size.

The surface is ornamented with very fine, close set, slightly irregular, transverse striæ, best seen by the aid of a good hand lens, some 15 to 20 of the striæ occupying half an inch space. The position of the siphuncle is obscure, and consequently its elements are indeterminable in the specimen. Tho transverse striæ do not lie parallel to the septa but surround the test in a sinuous manner, rising half an inch from the parallel, and falling again, the highest part of the curve being on the ventral aspect. The striæ appear to mark the lines of growth and thus indicate to some extent the form of the superior extremity of the shell.

There is also some slight indication of colour banding on the surface, the chambers being alternately lighter and darker, and of a brownish hue. The fossils associated with it in the same shales were:—several species of Nautili, some species of Temnocheilus, a large number of Goniatites, but of few species; fragments of Orthoceras, of small size, and Discites, together with Aviculopectens, and a number of Gasteropod Shells of the nature of Macrocheilus, Loxonema, and Rissoa, fish scales, bones, teeth, and plant remains.

Mr. HOLROYD said he must apologise for taking up the time of the meeting so late in the afternoon.

The CHAIRMAN: I am sure Mr. Holroyd need not apologise for bringing this matter before the Society. The only thing I regret is that so few members are here to hear the paper. We do not often have such an abundance of interesting papers as we have had to-day, and in moving a vote of thanks to Mr. Holroyd, I can only express my regret that we have not had a larger attendance.

Mr. S. ATHERTON: I have very great pleasure in seconding the motion.

The resolution was carried, and with that the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XXVII. SESSION 1900-1901.

The ORDINARY MEETING of the Members was held on Tuesday, June 11th, 1901, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. JAMES TONGE, M.Inst.C.E., F.G.S., (in the absence of the President), in the Chair.

NEW MEMBER.

The following gentleman, having been duly nominated, was elected a member of the Society:—

Mr. JOHN TAYLOR, of 51, Park Road, Darwen.

THE LATE MR. JOHN CROSS.

Mr. JOSEPH DICKINSON, F.G.S.: We have had before the Council, which met before this meeting, the death of an old member, a very highly esteemed Manchester Accountant and Agent, and most able man—Mr. John Cross,—and we proposed that a short memoir of him should appear in our

Annual Report, and that in the meantime we should send a letter expressing our sympathy and condolence with Mr. Cross's family. I move accordingly.

Mr. WILLIAM SAINT: I beg to second Mr. Dickinson's proposition.

The motion was approved.

The CHAIRMAN: The Secretaries have had some little difficulty in getting papers recently. It would be very gratifying to the Council if members would be good enough to think over what subjects they could throw light upon in geology or mining. In our difficulty Mr. Dickinson has kindly come forward, as he has on many other occasions, to supply the deficiency.

Mr. DICKINSON: I think one reason why we have had a lack of papers is that we are expecting our President to give us his promised paper. He is preparing, I think, a very elaborate paper, but has not quite completed it, and that has deterred some other people from preparing papers. Hence there was a request that members would prepare short papers. I have complied with the request by writing a short paper on "Gravitation of Firedamp," and I shall be glad if members will invest it with some importance by giving their views upon the subject in discussion.

The following paper on "Gravitation of Firedamp," was read by Mr. JOSEPH DICKINSON, F.G.S.:—

GRAVITATION OF FIREDAMP.

By Mr. Joseph Dickinson, F.G.S.

Most of those who are interested in mining noticed with sympathetic regret that, notwithstanding the manifest general improvement in the ventilation of collieries and the greatly increased use of safety lamps and selected explosives, startling great explosions still occasionally occurred. It was almost enough to make one think that some drawback, such as relaxed individual precaution, accompanied every wide-spread improvement.

In former times where safety lamps were used it was quite common to find accumulated firedamp, sometimes filling whole headings and occasionally the whole of one side of the pit, the protection against entering which was a signal prop or rail across the entrance. To admit of shots being fired in working faces of some such collieries accumulated firedamp had to be burned out in a special way, the result being, the lighting of numerous issuing jets of gas which had to be flapped out before the shot was fired; and again on their becoming relighted by the shot the flapping had to be repeated. Whilst in less fiery collieries where open lights were used the fireman's examination to see the places clear of gas for persons to enter was sometimes made with a safety lamp, but perhaps oftener with a small candle, 32 to the pound, safety having to be judged of by the intensity of blue cap on the flame, after which each person had similarly to judge of the continued safety of his own surroundings.

Added to this, with both kinds of lighting, blasting with gunpowder was practised all round, occasionally in air sufficiently contaminated with firedamp so as by compression

from a blown out shot to be readily detonated and help the flame. Such a blow out was aggravated when the drill hole was crooked or the stemming imperfect, which gave a twirl to the outburst and seemingly increased the detonating effect on the air, especially when helped with inflammable dust.

Such surroundings tended naturally to exercise the alertness of all persons exposed to the consequences, causing them to resort to various expedients for safety, such as lying down in the gutter or lowest place immediately on feeling the suck preceding the blast, so that flame and blast might pass over them.

This paper, however, is not intended to describe such individual precautions but as a reminder of danger from the gravitation of firedamp, which, as the opportunities for noticing are few, may be recalled for the benefit of those whose times have fallen mainly on pleasant lines.

The allusion is to the occasional increased incoming of firedamp into workings caused by atmospheric pressure being brought into operation by a new opening made in the vicinity, especially if on the dip, whether in the same colliery or adjacent thereto, such as by the sinking of a new shaft, or by a borehole, or by cutting through a fault, assisting the flow of firedamp without leaving a vacuum behind.

The first occurrence of this kind which he now remembers calling attention to, appeared in his official annual report 45 years ago. The occurrence was at a place called the Whins, in the township of Hapton, near Burnley, where from beyond the memory of man, coal had, after long periodical intervals, been worked on a very small scale for the supply of two outlying farm houses. The whole working consisted of a short level about 100 yards in length, driven from the outcrop in a seam of coal, with a pit 14 yards in depth, sunk to it for air and as a windlass pit. Firedamp had not been met with. Yet on work being resumed on this occasion after an

interval of four months an explosion of firedamp occurred, injuring two persons and killing another, the flame and blast rushing out of the shaft and blowing the windlass away.

It occurred on April 14th, 1855, and on his inspecting the place four days afterwards he found firedamp issuing from the windlass pit and the level mouth in sufficient quantity to preclude access into the workings.

The explanation which he then gave of this first appearance of firedamp in a place about 100 years old was that the sinking of a new winning to the seam 1,600 yards away from Whins had brought the atmospheric pressure to bear on the dip. That view was received very sceptically by the agent of the works who said he thought the idea too good to be true, faults being likely to intervene in the distance of nearly a mile. Since then the intervening space has, now long ago, been worked through, and proved to be without fault or other interruption to such passage of gas in the seam of coal.

So impressed was he with the importance of the occurrence as showing how firedamp gravitated with atmospheric pressure so brought to bear, that in addition to the mention of it in his report he afterwards, so far as lay in his power, endeavoured to have warning given to adjacent workers when an opening of any kind likely to bring atmospheric pressure to bear was about to be made, and he knew that on some occasions the warning proved useful.

Possibly the warning helped, but certainly with the improved management, better observance of rules, and increased use of safety lamps of an improved kind, the loss of life by explosions in his district during the last five years of his term of office as inspector of mines became reduced from large numbers to less than an average of one yearly, which good result had apparently been since even further improved.

Mr. SAINT: I beg to move that a hearty vote of thanks be given to Mr. Dickinson for his very useful notes on the subject of gravitation of firedamp. The paper has a special value at the present time, in my opinion, for it so happens, that on the dip of the Universal Colliery, where a disastrous explosion has just taken place, a new shaft has recently been sunk to the steam coal seams.

Mr. DICKINSON: Is that so?

Mr. SAINT: Yes.

Mr. DICKINSON: I was not aware that such a thing had taken place.

Mr. SAINT: They got down to the steam coal seams about a month ago.

Mr. DICKINSON: I was not aware when I wrote the paper that such gravitation was at all applicable to the South Wales disaster. In all the accounts I have seen, the disaster has been put down to an explosion of coal dust.

The CHAIRMAN: I have great pleasure in seconding the motion.

The motion was cordially adopted.

The CHAIRMAN: Mr. Joseph Dickinson is one of those gentlemen on whom, when we are wanting special information on any mining subject, we can confidently rely. To-day he has given us something quite fresh. I am very sorry to confess that in his paper this afternoon he has gone ahead of anything I had expected. I had never supposed such a thing as he seems to have done 45 years ago. It is quite a new theory to me, and I really feel I cannot quote any circumstance or occurrence in my own experience, either confirming or disproving Mr. Dickinson's view. But knowing Mr. Dickinson as I do, and remembering how many valuable

suggestions I have had from him, and how things he has told me of, and opinions he has given me have proved to be perfectly correct, I am quite inclined to take his theory as being probably a correct one. I am sorry it has not come within my observation before, and I really feel it is no use attempting to give opinions on things upon which you have had no previous thought: but in view of the startling fact, as I may call it, just mentioned by Mr. Saint, which goes strongly in favour of Mr. Dickinson's theory being a sound one, I cannot do otherwise than accept Mr. Dickinson's reasoning as correct. I shall be very much interested in the theory, and shall take care to test it when possible. I was also struck with Mr. Dickinson's reference to the way in which examinations for firedamp used to be made, sometimes with a safety lamp, but more frequently with a naked light. It is a striking comment on the proceedings of those days. It would appear that neglect accompanied every improvement. It has no doubt frequently been the case that improvements have been set aside, or we have failed to make use of them. For instance, I remember when the detaching hook came into use many proprietors were for a long time opposed to its introduction, for they said the enginemen would be so much more careless if they felt they were working in comparative safety, and the improvement would not be a real one, but would probably cause disaster. Mr. Dickinson has given us some very striking commentaries on the work of past times and the way in which examinations for firedamp were often made. I feel very much obliged to him for his paper.

Mr. PICKSTONE: I should like to ask Mr. Dickinson how the atmospheric pressure resulting from the opening of a shaft 1,600 yards away from the old workings operated, in his opinion.

Mr. DICKINSON: When a shaft is sunk the air percolates.

Mr. HARRISON: I have never heard of any views like those set forth by Mr. Dickinson in his paper. In that respect I am like Mr. Tonge. It seems that the idea now propounded was put forward in a report written over 40 years ago. That was before I had began to read reports, and the matter has not been mentioned since. I have been much interested in hearing Mr. Dickinson, and shall in future when I hear of an outburst of firedamp look round to see if a new shaft has been sunk in the neighbourhood. At present, however, I must confess my ignorance on the subject. I have read the Inspector's reports pretty regularly for 20 years, but 45 years is a little too far back for me. It is a little odd I have never heard of it, but anyhow I am glad the idea has been brought under our notice to-day.

Mr. DICKINSON: It seems from what some of the members have said that my bringing this subject before the meeting has not been inopportune. Although in my official report for the year 1855 a description of what I have now brought before you appears in fine bold type, printed by Messrs. Eyre & Spottiswoode, the discussion shows one how very little attention is paid to what one writes. Not one of you seems to have read my report, and I am not quite sure there is a copy of the report in the library. Until Mr. Saint informed us that a shaft had recently been sunk on the dip, or in the neighbourhood, of the Universal Colliery, where an explosion has taken place, I was not aware that any such sinking had been made. I had only on the receipt of the circular letter saying the President was unable to give us his promised paper, thought that recalling this subject might be useful, particularly to the rising generation, who had not had such occurrences brought under their notice; but if it be the case that such a winning has been made in the case of the colliery in South Wales, I hope the matter will be fully

inquired into, and that no one will run away with the idea of explosion from coal dust as the true solution without due inquiry. There is nothing like getting at the root of the thing and preventing similar occurrences. With regard to the question of Mr. Pickstone, how the atmospheric pressure from a bore on the dip could assist the firedamp in blowing up to the rise by its own gravity——

Mr. PICKSTONE: In a place where firedamp was previously unknown.

Mr. DICKINSON: The place where it was unknown was near the outcrop of the seam, and the firedamp could not get up there unless under very high pressure, which it had relieved itself of centuries before, and was unable to continue doing so unless an opening was made on the dip, otherwise it would have left a vacuum. Directly an opening was made at the dip the firedamp was not only allowed to rise but assisted by its own light specific gravity to rise to the outcrop. It almost carries its own explanation itself.

Mr. PICKSTONE: I should have supposed that the firedamp might have come up the new sinking, or rather the gas might have escaped from the new sinking rather than forced the gas along the incline up to the shallow workings.

Mr. DICKINSON: There is very little doubt some gas did escape into the shaft, but the gas that was moved up to the old workings at the outcrop was the gas that was left in the seam, between the shaft and the outcrop, a distance of 1,600 yards.

Mr. SAINT: The idea, I take it, is that the gas was held in tension until a new shaft was made and that then the firedamp would ascend and not descend, being only one-half the weight of atmospheric air. The pressure of the atmosphere would naturally carry it forward and it would flow out at the top.

The CHAIRMAN: It may be illustrated by an instance with which most of us are familiar. Take the case of a barrel containing liquid with a tap at one end. Turn the tap; no liquid comes out until you make a vent hole at some other point, then the atmosphere is allowed to act upon it and forthwith the liquid pours out at the tap. Before that it could not come out for there was as good as a vacuum behind it, as Mr. Dickinson has pointed out. As I understand Mr. Dickinson that is a familiar illustration of the process.

Mr. DICKINSON: Yes. Your illustration simply reverses the action of the fluids. I have described a fluid lighter than air. Mr. Tonge has described one heavier. The air went in at the vent hole and liquid came out at the tap. But in this instance in dealing with gas lighter than air the air went in at the bottom and gas came out at the vent hole.

Mr. PICKSTONE: It is very extraordinary it should force itself forward in that way by reason of the access of air through 1,600 yards of a seam of coal.

Mr. DICKINSON: It did not force itself. It came by gravity and atmospheric pressure.

Mr. PICKSTONE: Yes, but it seems extraordinary it should be so.

The CHAIRMAN: When we remember the pressure of gas in the coal, sometimes as much as 250 lbs. per square inch, we must know how tremendous is the pressure in some places. I do not see any improbability in the theory at all.

Mr. PICKSTONE: I don't see any, but I wanted to get from Mr. Dickinson his idea of the way in which this thing took place.

Mr. DICKINSON: Perhaps you did not catch this part of what I said: "So impressed was I with the importance of the occurrence showing how firedamp gravitated with atmospheric pressure so brought to bear, that, in addition to the mention in my report I afterwards, so far as lay in my power, endeavoured to have warning given to adjacent workers when an opening of any kind likely to bring atmospheric pressure to bear was about to be made, and I know that on some occasions the warning proved useful."

The CHAIRMAN, before the meeting separated, appealed to members for papers on any subject appertaining to mining or geology.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XXVII. SESSION 1901-1902.

The ANNUAL MEETING of the Members was held on Tuesday, October 8th, 1901, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Professor W. BOYD DAWKINS, M.A., F.R.S., F.G.S., &c., (in the absence of the President,) in the Chair.

NEW MEMBERS.

The following gentlemen were unanimously elected members of the Society, namely:—

Mr. HENRY W. B. COTTERILL, Waterworks Engineering Assistant, Hazlehead, near Sheffield.

Mr. W. H. COLEMAN, 4, Sunnyside Terrace, North Road, Clayton, Manchester.

Mr. W. A. SMETHURST, Manager, Garswood Hall Collieries, Brynn, near Wigan.

THE ANNUAL REPORT OF THE COUNCIL AND TREASURER'S STATEMENT.

Mr. WILLIAM SAINT, one of the Honorary Secretaries, read the Report of the Council, for the Session 1900-1901, as follows:—

REPORT OF THE COUNCIL,

FOR THE SESSION 1900-1.

The Council, in presenting their Sixty-third Annual Report, have pleasure in congratulating the members on the satisfactory position of the Society, both numerically and financially.

During the Sessional Year seven Ordinary Meetings were held in the Society's Rooms, 5, John Dalton Street, and one Meeting, in January, by the kind permission of the Governors, in the Mining School, Wigan.

In revising the list of Members, it is found that there has been a loss of eight Ordinary Members by death, and three by resignation. Twelve Ordinary Members have been elected.

The losses by death, which we regret to record, include some of our old supporters amongst whom may be mentioned Mr. George C. Caldwell, Mr. William Bryham, Mr. John Cross, Mr. T. E. West, Mr. H. A. Woodward, and Mr. G. C. Greenwell, senior, an ex-President; the others being Mr. Thomas Arrandale, Mr. James McGeever, and Mr. David Shaw.

The Society now consists of :—

Honorary Members	11
Life Members	9
Ordinary Members	215
Total	235

At the Annual Meeting, an instructive and interesting lecture on "Golden Victoria" illustrated with numerous lantern slides showing the varied landscapes and mineral wealth of the Colony, was given by Mr. James Stirling, the Mining Representative of the Colony of Victoria.

Papers and short communications on Geological Subjects were contributed by Mr. Lionel B. Wells, Mr. C. E. DeRance, Messrs. Barnes & Holroyd, Mr. Mark Stirrup, Mr. Joseph Dickinson, and Mr. W. Baldwin: and on Mining Subjects by Mr. Henry Hall, Mr. Joseph Dickinson, Mr. Thomas Aspinall, and Mr. J. W. Hutchinson, some of which gave rise to interesting discussions.

Mr. Stirrup also contributed interesting Geological and Industrial notes on the Paris Exhibition.

Mr. W. Watts, who was appointed by the Council as their delegate to the Meeting of the British Association for the Advancement of Science held at Bradford in September, 1900, favoured the Society with a Report which appears in the Transactions.

The President, owing to pressure of business engagements, was unable to read his promised paper during the past year.

A complete list of the papers and short communications read during the Session is appended.

The Council most heartily thank the authors for their valued contributions, some of which add to our knowledge

of the Geology of the British Empire, while others treat of practical mining operations, having for their object the safe and economical working of our coal and other mineral deposits, thus showing a commendable interest in the welfare of the Society, which the Council hope to see increased in the coming Session.

While congratulating the Society on the results shown, which are owing principally to the labours of a few of its most active members, the Council respectfully invite the larger number to take a personal interest by attending the meetings, contributing papers for discussion, and generally in promoting the efficiency of the Society, whose objects are the collection and diffusion of practical knowledge respecting Geology and Mining.

The Balance Sheet, giving the particulars of expenditure and receipts, prepared by the Honorary Treasurer and duly audited, is appended, and its examination will show the Society's finances to be satisfactory.

The Council are pleased to announce that the Certificate of the Registrar of Friendly Societies has been obtained, which entitles the Society to exemption from County Borough, Parochial, and other local rates for lands and buildings occupied by them.

The Certificates for the Society's investments, consisting of £600 Birkenhead Railway Consolidated Stock (Guaranteed), and £733 Lancashire and Yorkshire Railway 3 per Cent. Consolidated Preference Stock, have been deposited in a locked box, the keys of which are held by the Trustees, Mr. Joseph Dickinson, F.G.S., and Mr. Lees Knowles, M.P., LL.D., in the St. Ann's Branch of the Williams Deacon and Manchester and Salford Bank, Limited.

The Council, for economical reasons, have now arranged for the Annual Subscriptions to be received at the Society's

Rooms, and the Members are requested to note the change. All Cheques and Postal Orders should be crossed / & Co., and made payable to Mr. George H. Hollingworth, the Honorary Treasurer.

The usual technical journals, such as the Colliery Guardian, Mining Journal, Coal and Iron Trades Review, Science and Art of Mining, Geological Magazine, &c., and the publications of the various Societies with whom we exchange Transactions continue to be received, and these, together with the valuable library and geological maps on the one-inch and six-inch scales, are available for reference by the members on weekdays, between the hours of 9-30 a.m. and 5-30 p.m., except on Saturdays, when the Rooms are closed at 1 p.m. It is desired that these facilities for reference may be more generally made use of by the members. All are cordially invited to introduce their friends to the meetings, and thus in some degree assist in making its valuable work more generally known.

FINANCE.

Mr. SAINT also read the following abstract of the Honorary Treasurer's accounts:—

Dr. MANCHESTER GEOLOGICAL SOCIETY.—ABSTRACT OF ACCOUNTS FOR THE YEAR 1900-1. *Cr.*

1900. Receipts.	£	s.	d.	£	s.	d.
Oct. 2.—To Balance in Bank				10	1	1
1901.						
Sept. 30.— ,, Members' Subscriptions:—						
Current	163	10	0			
1902	1	0	0			
Arrears	18	0	0			
				181	10	0
To Dividends:—						
Birkenhead Railway	22	15	0			
Lancashire & Yorkshire Railway.	20	16	11			
				43	11	11
,, Bank Interest				0	6	1
,, Hire of Rooms				7	4	6
,, Sale of Transactions				2	9	8
,, Sundry Receipts				0	0	9
				£245	4	0

1901. Payments.	£	s.	d.
Sept. 30.—By Rent and Expenses of Room	81	15	6
,, Printing Transactions	69	6	1
,, Circulars and Stationery	9	19	0
,, Postages, &c.	13	4	1½
,, Reporters	8	8	0
,, Library	1	14	5
,, Law Charges, &c.	1	1	0
,, Collector's Commission, &c.	10	19	7
,, Sundry Expenses	1	10	0½
,, Balance in Bank	47	6	3
	£245	4	0

Dr. BALANCE SHEET, 30th September, 1901. *Cr.*

Liabilities.	£	s	d.
To Outstanding Accounts:—			
J. Roberts & Sons	29	18	0
J. E. Cornish	0	4	6
Manchester Corporation	0	8	4
	£30	10	10
,, Balance	2064	8	11
	2094	19	9

Assets.	£	s.	d.
By £600 Birkenhead Railway Consolidated Preference Stock Guaranteed (at £130½)	783	0	0
,, £733 Lancashire & Yorkshire Railway 3% Consolidated Preference Stock (at £97⅛)	714	13	6
,, Library and Furniture, say	500	0	0
,, Cash in Bank	47	6	3
,, Arrears of Subscriptions, £131 10s., say	50	0	0
	£2094	19	9

The Investments consist of £600 Birkenhead Railway Consolidated Stock (Guaranteed), and £733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock. The Certificates for these are deposited at the Williams Deacon and Manchester and Salford Bank, St. Ann's Street Branch, and were inspected by me this 7th October, 1901. (Signed) JON. BARNES.

Audited and found correct, October 7th, 1901,

JON. BARNES,
GEO. H. WINSTANLEY, } Auditors.

GEO. H. HOLLINGWORTH,
Honorary Treasurer.

Mr. JOSEPH DICKINSON, F.G.S.: I beg to propose that the Report and Balance Sheet now read be adopted. One cannot help feeling sorry to learn that so many members of the Society have died during the year. Some of them have already been notified in the Transactions, such as Mr. Caldwell and Mr. Greenwell, senior. Mr. Woodward, a very old member, is also in the list of deaths. We only received the announcement of his death two or three days ago. He was a person who took a very active part in mining in this district for many years, and though not an old man like some others, he seemed to fall off in his attendances, and gradually retired from active work. I can truly say he has on one or two very notable occasions assisted me most materially in explorations underground after an explosion. This was especially the case at the Unity Brook Colliery, when he and the manager of the Colliery, and the late Mr. Grimshaw and myself explored the whole mine before it was thrown open to the public. I feel his loss very much. He was a very useful member. He had always something interesting to say, and some useful information to give us.

Mr. GEORGE PEACE seconded the motion, and it was adopted.

ELECTION OF OFFICERS.

The CHAIRMAN said: As usual, the Council have prepared a list of members of the Society whom they recommended for election to fill the various offices, subject to the approval of the Meeting.

The Officers of the Society, for the ensuing year, were appointed as follows:—

Professor BOYD DAWKINS moved, and Mr. JOSEPH DICKINSON seconded, that Mr. Jonathan Barnes, F.G.S., be appointed President for the Session.

The proposal was unanimously adopted.

The following were unanimously elected to be Vice-Presidents:—

Messrs. W. F. Holroyd, F.G.S.; Lionel B. Wells, M.Inst.C.E.; John Gerrard, H.M.I.M.; A. Dury Mitton, Assoc.M.Inst.C.E.

Mr. G. H. Hollingworth, F.G.S., was re-elected to the office of Honorary Treasurer.

On the motion of Mr. JOSEPH DICKINSON, seconded by Mr. J. BARNES, Messrs. William Saint, H.M.I.M., and James Tonge, junr., F.G.S., were re-appointed to be Honorary Secretaries.

The following gentlemen were appointed members of the Council in addition to the above-named Officers, namely:—

Messrs. John Ashworth, Ernest Douglas, Frank J. Grant, George B. Harrison, John Knowles, A. H. Leech, D. H. F. Matthews, W. W. Millington, George Peace, John Rigby, Harry Speakman, and Thomas Ward.

The Past-Presidents continue, under the Rules, *ex-officio* members of the Council.

Mr. W. F. Holroyd was re-elected to be Honorary Librarian.

Mr. J. Barnes and Mr. George H. Winstanley were re-elected Honorary Auditors.

On the motion of Professor DAWKINS, a vote of thanks was given to the Officers and Council for their services during the past Session.

At the close of the ordinary business the Chairman invited the members to a meeting of the Lancashire and Cheshire Antiquarian Society, which was to be held on the following Friday evening, at the Owens College. He said there will be an exhibition of the implements about which there has been so much writing lately in the newspapers—palæolithic implements, found by various people, including Mr. Auberon Herbert and others, in the South of England. I shall be extremely pleased to see any members of this Society who care to come. It is quite an informal affair, and I shall be very pleased if they come to show them what we are doing. While speaking on this matter, let me say I do really think it is about time the Society held a meeting in the Museum which it had such a very large share in founding. For some two or three years I don't think you have honoured us, and, speaking on the part of the Museum, I can say it would be a great pleasure if you could arrange in the course of next session for some such visit. I think it would be very useful. You would see the improvements made and we should greatly benefit by the suggestions which some of you might be good enough to make.

Mr. MARK STIRRUP: I may say I called to see you not more than a fortnight ago with regard to a meeting of this

Society, at the Owens College. I felt no doubt at all in my own mind we should be received with hospitality and great pleasure, but as you were absent—I don't know whether you were aware of the fact—no meeting was arranged. We have had verbal promise of a room from the authorities of the College, but that promise is being held over until next month, and arrangements are being made with Professor Stirling, the Agent for the Victorian Government, at present in England. With regard to a meeting, we have usually had one, I may say, in the off time, in January, when it has been our pleasure to go and see the Museum, and what additions have been made to it, and I think it is quite as well that that plan should be adhered to in future, because it keeps us in touch with the Museum, which, as you say, we have had so much to do with in earlier days. Much of the valuable material in the College now was really belonging at one time to the Manchester Geological Society. It is now something over 60 years since the Society was instituted. I think it is a great pity that we have not more members of a Society so ancient as our own to carry on the work, because the work cannot be less than it was at that time.

A vote of thanks was accorded to the Chairman for presiding, on the motion of Mr. James Tonge, senior, seconded by Mr. W. Ollerenshaw.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE SOCIETY

DURING THE SESSION 1900-1901.

1900.

November. Stirrup, Mark, F.G.S. "Notes—Geological and Industrial—from Paris Exhibition."

"The Great Siberian Railway."

Wells, Lionel B., M. Inst. C.E. "Section of Strata, above the Barnsley Coal, passed through in the borehole at South Carr, Lincolnshire, under the direction of Messrs. A. Wilson and G. Dunstan."

December. Barnes, J., F.G.S., and Holroyd, W. F., F.G.S. "On the Origin of the Pebbles in Limestone Conglomerate, occurring near Windy Knoll."

Watts, William, F.G.S., &c. "Report of the Delegate to the British Association Meeting at Bradford, September, 1900."

De Rance, Charles E., F.G.S., Assoc.M.Inst.C.E., M.Inst.M.E., &c. "On Sulphur and Pyrites in relation to Sulphuric Acid and its applications."

1901.

January. Hutchinson, J. W. "On the Working of the Double Ventilating Fans recently erected at Bamfurlong Collieries."

February. Dickinson, Joseph, F.G.S. "Notes on Castle Irwell, Pendleton, Manchester."

Aspinall, Thomas, F.I.C. "On the Accumulation of Solid Matter in Steam Boilers, and how to minimise the troubles caused thereby."

March. Pickstone, William. "On Mining in South Africa."

April. Baldwin, William. "On *Prestwichia Rotundata* found at Sparth Bottom, Rochdale."

Dickinson, Joseph, F.G.S. "On Prevention of Accidents by Falls of Roof and Sides in Coal Mines."

Barnes, J., F.G.S., and Holroyd, W. F., F.G.S. "On a Fossil found in the Shales below Millstone Grit, Pule Hill, Marsden."

June. Dickinson, Joseph, F.G.S. "On Gravitation of Fire-damp."

NEW ORDINARY MEMBERS.

Baldwin, William
Banks, Thomas
Brancker, Richard
Burke, Harry
Champ, Henry
Elce, Abraham, Junr.
Knight, Henry
Maxwell, Frank
Mc.Kay, William
Pickstone, William
Ridyard, George
Taylor, John

MEMBERS DECEASED.

Arrandale, John Thomas
Bryham, William
Caldwell, George
Cross, John
Greenwell, G. C.
Mc.Geever, James
West, T. E.
Woodward, H. A.

MEMBERS RESIGNED.

Brierly, Brandon T. | Goodwin, John | Hall, William

The following is the complete list of the Council for the ensuing year :—

President:

JONATHAN BARNES, F.G.S.

Vice-Presidents:

W. F. HOLROYD, F.G.S. | A. DURY MITTON, Assoc.M.Inst.C.E.
JOHN GERRARD, H.M.I.M. | LIONEL B. WELLS, M.Inst.C.E.

Ex-Officio Vice-Presidents:

R. CLIFFORD SMITH, F.G.S.
The Right Hon. the EARL OF CRAWFORD & BALCARRES.
Sir U. J. KAY-SHUTTLEWORTH, Bart., M.P.
EDWARD PILKINGTON, J.P.
Professor W. BOYD DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
HENRY HALL, H.M.I.M. | JOHN S. BURROWS, F.G.S.
JAMES TONGE, F.G.S., Assoc.M.Inst.C.E.
W. SAINT, H.M.I.M. | MARK STIRRUP, F.G.S.
ROBERT WINSTANLEY, C.E. | JOHN RIDYARD, F.G.S.
W. WATTS, F.G.S. | W. S. BARRETT, J.P.
G. C. GREENWELL, M.Inst.C.E., F.G.S.

Hon. Treasurer:

G. H. HOLLINGWORTH, F.G.S.

Hon. Secretaries:

WILLIAM SAINT, H.M.I.M. | JAMES TONGE, Jun., F.G.S.

Other Members of the Council:

JOHN ASHWORTH, C.E. | D. H. F. MATHEWS, H.M.I.M.
ERNEST DOUGLAS. | W. W. MILLINGTON.
FREDK. J. GRANT. | GEO. PEACE.
GEO. B. HARRISON, H.M.I.M. | JOHN RIGBY.
JOHN KNOWLES. | HARRY SPEAKMAN.
A. H. LEECH. | THOMAS WARD, J.P., F.G.S.

Hon. Librarian:

W. F. HOLROYD, F.G.S.

Hon. Auditors:

J. BARNES, F.G.S. | GEO. H. WINSTANLEY, F.G.S.

Trustees:

JOS. DICKINSON, F.G.S. | LEES KNOWLES, M.A., LL.D., M.P.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-39-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-46-47	Moseley, Sir Oswald, Bart.
1847-48-49	Thicknesse, Ralph, M.P., Wigan
1851-52-53	Black, James, M.D., F.G.S.
1853-54-55	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-61	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-74	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Prof. W. Boyd, M.A., F.R.S., F.G.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P.
1881-82	Gilroy, George, M.Inst.C.E.
1883-84	Pilkington, Edward, J.P.
1885-86	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.
1897-98	Ridyard, John, F.G.S.
1898-99	Livesey, Clegg, J.P.
1899-1900	Barrett, W. S., J.P.
1900-01	Greenwell, G. C., F.G.S., M.Inst.C.E.

APPENDIX TO THE REPORT.

ADDITIONS TO THE LIBRARY, 1900-01.

To September 30th, 1901.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1899-1900. *From the Society.*

Birmingham.—South Staffordshire and East Worcestershire Institute of Mining Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Bradford.—Annual Report (30th) of Libraries and Art Museum Committee.

Bristol.—Naturalists' Society. Proceedings. New Series, Part 2 Vol. IX.

Cambridge.—Museum. 35th Annual Report Museums and Lecture Rooms' Syndicate for 1900; also Annual Report of the Library, 1900. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Report and Transactions for 1899-1900. Vol. XXXII. *From the Society.*

Cardiff.—South Wales Institute of Engineers. Proceedings. Nos. 2, 3, 4, 5, Vol. XXII. *From the Institute.*

Chester.—30th Annual Report of Chester Society of Natural Science and Literature for 1900. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Congleton.—North Staffordshire Institute of Mining and Mechanical Engineers. Part 1, 2, 3, 4, 5, Vol. XV. Parts 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Vol. XVI.

Dublin.—The Beauforts Dyke off the Coast of the Mull of Galloway, by G. H. Kinahan. *From the Royal Irish Academy.*

Edinburgh.—Royal Geological Society. Transactions. Part 1, Vol. VIII. *From the Society.*

Edinburgh.—Royal Physical Society. Proceedings. Part 3, Vol. XIV. *From the Society.*

Glasgow.—Geological Society. Transactions. No. 2, Vol. XI.

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Hertford.—Hertford Natural History Society and Field Club. Transactions. Parts 4, 5, 7, 8, Vol. X. *From the Society.*

Leeds.—Yorkshire Geological and Polytechnic Society. Proceedings. Part 1, Vol. XIV.

Leeds.—Yorkshire Naturalists Union. Transactions. Part 22, for 1896; Part 23, for 1897; Part 24, for 1898; Part 25, for 1899; Part 26, for 1900.

Leeds.—Literary and Philosophical Society. Annual Report, 1900.

Leicester.—Literary and Philosophical Society. Transactions. Parts 9, 10, 11, 12, Vol. V., New Series. *From the Society.*

Liverpool.—Geological Society. Proceedings. Part 4, Vol. VIII.

Liverpool.—Science and Art Student's Annual Report, 1899-1900.

Liverpool.—Public Libraries and Art Galleries. 48th Annual Report, 1900.

London.—British Association for the Advancement of Science. Reports for 1900. *From the Association.*

London.—British Museum. Juarassic Flora of Yorkshire.

London.—Geological Magazine. (New Series.) Decade IV. Nos. 10, 11, and 12, Vol. VII. Nos. 1-9, Vol. VIII. *Purchased.*

London.—Geological Society. Quarterly Journal. No. 224, Vol. LVI. Nos. 225, 226, 227, Vol. LVII. *From the Society.*

London—Geological Literature. Added to the Geological Society's Library, 1900.

London.—Geologists' Association. Proceedings. Part 10, Vol. XVI. Parts 1, 2, 3, Vol. XVII. *From the Association.*

London.—Institution of Mechanical Engineers. Proceedings. Nos. 1, 2, 3, 4, 1900. Nos. 1, 2, 1901, and List of Members. *From the Institution.*

London.—Iron and Coal Trades' Review. Nos. 1701 to 1713, Vol. LXI. Nos. 1714 to 1739, Vol. LXII. Nos. 1740 to 1752, Vol. LXIII.

London.—Iron and Steel Institute. Journal. Vols. LVIII. and LIX. *From the Institute.*

London.—Palaeontographical Society. Vol. LIV., for 1900. *Purchased.*

London.—Royal Society. Proceedings. Nos. 435 to 441, Vol. LXVII. Nos. 442 to 450, Vol. LXVIII., and the Reports of the Malaria Committee for 1900 and 1901. *From the Society.*

London.—The Colliery Guardian. Nos. 2075 to 2087. Vol. LXXX.; Nos. 2088 to 2113, Vol. LXXXI.; Nos. 2114 to 2126, Vol. LXXXII.

London.—The Mining Journal. Nos. 3397 to 3410, Vol. LXX. Nos. 3411 to 3449, Vol. LXXI.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Part 5, Vol. XLIV. Parts 1, 2, 3, 4, Vol. XLV. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 4 to 12, Vol. XVI. Nos. 1 to 3, Vol. XVII., and Supplement. Nos. 9 to 12, Vol. XIV. *From the Society.*

Manchester.—Association of Engineers. Transactions, 1900.

Manchester.—Field Naturalists Society. Report and Proceedings for the year 1900.

Manchester.—The Owens College Museum. Report for the year 1900 and 1901. Publication. No. 33. *From the College.*

Newcastle-upon-Tyne.—Institution of Mining Engineers. Transactions. No. 6, Vol. XVIII. Nos. 1, 2, 3, 4, 5, 6, Vol. XIX. Parts 1, 2, 3, 4, Vol. XX. Parts 1, 2, Vol. XXI.

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Institution of Mining Engineers; also Annual Report, 1899-1900. *From the Institution.*

Penzance.—Royal Geological Society of Cornwall. Transactions. Part 6, Vol. XII.

Salford.—The Fifty-second Annual Report of Libraries, Museum, and Parks Committees for the Borough of Salford, 1899-1900.

Stafford.—North Staffordshire Field Club. Annual Report and Transactions for 1900 and 1901. *From the Club.*

Stoke-on-Trent.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Truro.—Royal Institution of Cornwall. Journal. Nos. 1 and 2, Vol. 14.

Wigan.—Science and Art of Mining. Nos. 4 to 26, Vol. XI. Nos. 1 to 3, Vol. XII.

BOOKS, PAMPHLETS, AND REPORTS.—ENGLISH AND FOREIGN.

Mineral Statistics of the Mines and Quarries. Parts 3 and 4, 1899; Parts 1 and 2, 1900; also H.M. Inspector's Report of Mines and Quarries for the S. W. District for 1900. London. *Presented by Mr. Joseph S. Martin.*

General Report and Statistics for 1899.

Report to His Majesty's Secretary of State for the Home Department on the circumstances of an Explosion of Firedamp, which occurred on the 28th February, 1901, at the Blaendare Slope Colliery, Pontypool, Monmouthshire, by S. T. Evans, Esq., K.C., M.P., and J. S. Martin, Esq., H.M. Inspector of Mines.

Mines and Quarries. Report for 1900 for the North Staffordshire District, by W. N. Atkinson. *Presented by the Author.*

Report of Four Inspectors of Mines to H.M's. Secretary of State for the Home Department on the Methods of Preventing Falls of Roof adopted at the Courrières Collieries. *Presented by Mr. John Gerrard.*

Methods of Preventing Falls of Roof. *Presented by Mr. John Gerrard.*

Geological Map of Liverpool, by G. H. Morton, F.G.S. *Presented by Miss Morton.*

Adelaide.—Record of the Mines, South Australia.

Report of Geological Exploration of the Tarcoola District.

Report on Gold Discovery at Tarcoola.

Queensland Government Mining Journal. *Presented by the Agent-General for Queensland.*

Review of Reviews for Australia. *Presented by the Agent-General for Queensland.*

Report of the Geology (and Joint Report) of British Guiana. *Presented by Mr. J. D. Harrison.*

Report on the Geology of Mazaruni and Puruni Rivers. *Presented by Mr. J. D. Harrison.*

Mineral Resources of New South Wales. *Presented by the Agent-General for New South Wales.*

Manchester Faces and Places. *Presented by Mr. Joseph Dickinson.*

Phyllades of the Ardennes. By P. Holland, F.G.S., and T. Mellard Reede, C.E., F.G.S. *Presented by the Authors.*

Correspondence in the matter of the Society of Arts. *Presented by Dr. H. Wilde.*

Subsidence in and around the town of Northwich, in Cheshire. By Mr. Thomas Ward. *Presented by Mr. L. B. Wells, C.E.*

Notes on Drainage Areas. By William Watts, M.Inst., M. & M.E., F.G.S., &c. *Presented by the Author.*

Report on the Brown Coal Industry in Germany and Austria. By Mr. James Stirling.

Victoria.—Geological Survey of. *Presented by Mr. James Stirling.*

India.

Calcutta.—Memoirs of the Geological Survey of India. No. 2, Vol. XXVIII.; No. 2, Vol. XXX.; and No. 1, Vol. XXXIII.

Australia.

Adelaide.—Royal Society of South Australia. Transactions. Part 2, Vol. XXIV. Records, Nos. 3 and 4, Vol. I. *From the Society.*

Geological Map of South Australia.

Brisbane.—Annals of the Queensland Museum. Occasional Notes, No. 5.

Brisbane.—Annual Report of the Under Secretary for Mines. Queensland. *1900.*

Melbourne.—The Australian Mining Standard. Nos. 615 to 633, Vol. XVIII.; Nos. 634 to 660, Vol. XIX.; Nos. 661 to 666, Vol. XX. *From the Editor.*

Melbourne.—Geological Society of Australia. Native Coppers of the West Coast of Tasmania.

Sydney.—Geological Survey of New South Wales: Department of Mines. Records. No. 1, Vol. III. Part 4, Vol. VI. Mineral Resources, No. 8. Memoirs, No. 2. *From the Hon. the Minister of Mines.*

Sydney.—Royal Society of New South Wales. Journal and Proceedings. Vol. XXXII., and Vol. XXXIII.

Sydney.—Mineral Resources of New South Wales, and Annual Report of the Department of Mines and Agriculture. *From the Hon. the Minister of Mines.*

Sydney.—Australian Museum. Report of Trustees for the year 1899.

Canada.

Halifax.—N.S.—Nova Scotian Institute of Science. Proceedings and Transactions. Part 2, Vol. X., 2nd Series. *From the Institute.*

Hamilton.—Hamilton Association. Journal and Proceedings for 1898-9. No. 16. *From the Association.*

Ottawa.—Canadian Mining Institute. Journal. Vol. IV.

Ottawa.—Geological Survey of Canada. *From the Director of the Survey.*

Ottawa.—Relief Map of Canada and the United States, 1900.

St. John, New Brunswick.—Natural History of New Brunswick. Bulletin 19. Part 4, Vol. IV. *From the Society.*

Toronto.—Canadian Institute. Proceedings. Part 10, Vol. II., and Vol. IV. *From the Institute.*

Toronto.—Bureau of Mines. Reports for 1900 and 1901.

U.S. AMERICA.

Baltimore.—Maryland Geological Survey. Vol IV. *From the State Geologist.*

Baltimore.—Maryland Weather Service. Vol. II.

Baltimore.—Official Publication of the Maryland Commissioners, on the Pan-American Exposition.

Buffalo.—Buffalo Society of Natural Sciences. Bulletins. No. 1, Vol. VII.

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. Vol. XXXVI., Nos. 2, 3, 4, 5, 6, 7, 8; Vol. XXXVIII., No. 5. Annual Report of the Museum of Comparative Zoology for 1899-1900. *From Alex. Agassiz.*

Cambridge.—Harvard College. Geological Series, Nos. 1, 2, 3, Vol. V.

Chapel Hill, N. Carolina.—The Elisha Mitchell Scientific Society. Journal. Part 1, Vol. VII. 1900.

Chicago.—Field Columbian Museum. Annual Report for 1899-1900. Geological Series. Nos. 1, 2, 3, Vol. III. Zoological Series. Nos. 8 and 18, Vol. I.; No. 3, Vol. II. *From the Museum.*

Denver.—Colorado Scientific Society. Proceedings. Vol. VII. *From the Society.*

Indianopolis.—Mineral Resourses. 25th Report (1900).

Iowa.—Geological Survey of. Vol. X. *From the Director of the Survey.*

Madison.—Wisconsin Academy of Science, Arts, and Letters, Transactions. Part 2, Vol. XII.; No. 1, Vol. XIII.

Madison.—Wisconsin Geological and Natural History Survey. Bulletin. Nos. 5, 6; No. 2 Scientific Series.

Minneapolis,—The American Geologist. Nos. 3, 4, 5, 6, Vol. XXVI.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXVII.; and Nos. 1, 2, 3, Vol. XXVIII. *Purchased.*

New York.—The American Museum of Natural History. Bulletin. No. 3, Vol. XI.; Vol. XIII.; also Annual Report for 1900. *From the Museum.*

New York.—American Institution of Mining Engineers. Transactions. Vols. XXIX. and XXX. 1900.

New York.—Stone. Nos. 3, 4, 5, 6, Vol. XXI.; Nos. 1, 2, 3, 4. 5, 6, Vol. XXII.; No. 1, Vol. XXIII. *Presented by the Publisher.*

Philadelphia.—Franklin Institute. Journal. Nos. 4, 5, 6, Vol. CL.; Nos. 1, 2, 3, 4, 5, 6, Vol. CLI.; Nos. 1, 2, 3, Vol. CLII. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2, 3, 1900; Part 1, 1901. *From the Academy.*

Philadelphia.—American Philosophical Society. Proceedings. No. 162, 163, 164, Vol. XXXIX.; No. 165, Vol. XL.

Rock Island, Ill.—Augutana Library Publications, No. 2.

Scranton, Pa.—"Mines and Minerals." Nos. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. XXI.; Nos. 1, 2, Vol. XXII. *From the Editor.*

Washington.—Smithsonian Institute. Report of the U.S. State Museum, 1898 and 1899.

Washington.—Smithsonian Institute. Five Papers out of Report for 1898, and seven Papers out of Report for 1899.

Washington, U S.—Geological Survey. Monographs XXXIX. and XL. 19th Annual Report. Parts 3, 4, 7. 20th Annual Report. Parts, 2, 3, 4, 5, and Maps for Part 5. Bulletins 163 to 176, Folios 38 to 71. Standard Topographic Maps, 187.

Washington.—U.S. Board of Geographical Names. 2nd Report. 1899-1900, and Special Report.

Washington.—U.S. Geological Survey. Preliminary Report on the Cape Nome Gold Region, Alaska.

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 3, 4, 5, 6, Vol. XXXV.; Parts 1, 2, Vol. XXXVI. Verhandlungen, Parts 7, 8, 9, 10, Vol. XXVII.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXVIII. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft, Nos. 2, 3, 4, Vol. LII.; No. 1, Vol. LIII. *From the Society.*

Brussels.—Société Royale Malacologique de Belgique. Annales Vol. XXXIV. and Vol. XXXV. *From the Society.*

Buenos Aires.—Demografic Argentine. Bulletin. Parts 3, 4, 5.

Buenos Aires —Comunicaciones del Museo Nacional de Buenos Aires. Parts 8, 9, Vol. I.

Caen.—Société Linnéenne de Normandie (5th Series), Vol. III. *From the Society.*

Christiania.—Archiv. Mathematick og Naturvideushab. Part 4, Nol. XXI.; Parts 1, 2, 3, 4, Vol. XXII.

Dresden.—"8 Isis," January—December, 1900. *Presented by Naturwissenschaftliche Gesellschaft Isis.*

Freiburg.—Naturforschenden Gesellchaft, Berichte. No. 3, Vol. XI.

Iglo.—Jahrbuch des Ungarischen Karpathen-Vereines. No. XXVIII.

Halle A/S.—Mittelungen der Vereins für Erdkunde zu Halle A/S. 1900.

Keiff (Russia)—La Société des Naturalistes Memoirs. No. 2, Vol. XVI.

Lausanne.—Société Vaudoise. Bulletins Nos. 137-138, Vol. XXXVI.; Nos. 139-140, Vol. XXXVII.

Leipzig.—Geologisches Centrablatt. Part 1, Vol. I.

Lille.—Société Géologique du Nord. Annales, Vol. XXVIII., 1899.

Mexico.—Sociedad Científica "Antonio Alzate." Memorias Y. Revista. Nos. 7, 8, 9, 10, 11, 12, Vol. XIV. Nos. 1, 2, 3, 4, 5, 6, Vol. XV.

Mexico.—Institute Geologies des Mexico Boletins. No. 14.

Montevideo.—Annales del Museo Nacional. Nos. 14, 15, 16, 17, 18, 19, 20, Vol. III.

Naples.—Rendiconti dell' Accademia della Scienze Fisiche e Mathematiche. Parts 8, 9, 10, 11, 12, Vol. VI.; Parts 1, 2, 3, 4, 5, 6, 7, Vol. VII. *From the Academy.*

Paris.—Société de Spéléogique. "Spelunca." Nos. 21, 22, Vol. VI. *From the Society.*

Paris.—Société Géologique de France. Bulletin. No. 7, Vol. XXVI.; Nos. 5, 6, Vol. XXVII.; Nos. 1, 2, 7, 8, Vol. XXVIII.

Pisa.—Atti della Societa Toscana. Bulletin. Vol. XVII.

Pisa.—Societa Toscana de Scienze Naturale. Vol. XII.

Rome.—Atti della Reale Accademia dei Lincei. Rendiconti. Nos. 6, 7, 2nd Series, Vol. IX.; Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1st Series, Vol. X.; Nos. 1, 2, 3, 4, 5, 2nd Series, Vol. X. *From the Academy.*

St. Petersburg.—Comité Geologique. Bulletin. Nos. 1-6, Vol. XIX. Memoirs. No. 5, Vol. IX.; No. 3, Vol. XIII.; No. 3, Vol. XV. *From the Society.*

St. Petersburg.—Russ. Kaiser Mineralog. Gesellschaft. Verhandlungen. No. 2, Vol. XXVII.; Nos. 1, 2, Vol. XXVIII. Materials for Russian Geology. Vol. XX.

St. Petersburg.—L'Académie Impériale des Sciences. Bulletin. Nos. 2, 3, 4, 5, Vol. XII.; Nos. 1, 2, 3, Vol. XIII. *From the Academy.*

Stockholm.—Académie Royale Suédoise des Sciences. Bulletin. No. 24. Memoirs 29 and 30.

Stockholm.—Bihang Fill Krongl Svenska Velenskaps Akademiens Handlingar. No. 1.

Upsala. Geological Institution of Upsala. Bulletin. Vol. V.

SOCIETIES WITH WHICH THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHICH A COPY IS SENT FREE.

I.—ENGLAND.

London .....British Association for the Advancement of Science, Burlington House, London.

British Museum, The Superintendent, Copyright Office.

British Museum Library, Natural History Department, Cromwell Road, Kensington.

Geological Society, Burlington House, W.

Geological Survey, Jermyn Street, S.W.

Geologists' Association, University College, Gower Street, W.C.

Institution of Mechanical Engineers, Storey's Gate, St. James' Park, Westminster, S.W.

Iron and Steel Institute, 28, Victoria Street, S.W.

Royal Institution of Great Britain, Albemarle Street.

Royal Society, Burlington House, W.

Public Library, Kensington, High Street, W.

Manchester .....The Manchester Association of Engineers, Grand Hotel, Aytoun Street.

Field Naturalists' Society.

Free Library, King Street.

Literary and Philosophical Society, 36, George Street.

Manchester Geographical Society, 16, St. Mary's Parsonage.

The Owens College.

Salford Royal Museum and Library.

Barnsley.....Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.
South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol .....Naturalists' Society, Clifton.

Cambridge .....Geological Museum, University.
University Library.

Cardiff .....Cardiff Naturalists' Society, 44, Loudoun Square.
South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester .....Society of Natural Science, Grosvenor Museum.

Chesterfield .....Chesterfield and Midland Counties Institution of Engineers (G. A. Lewis, Secretary, Albert Street, Derby).

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.
Mining Association and Institute of Cornwall, Tuckingmill, Camborne.

Essex .....Essex Field Club, Passmore-Edwards Museum, Romford Road, Stratford, Essex.

Exeter.....Albert Memorial Museum.

Leeds .....Philosophical and Literary Society.
Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, 259, Hyde Park Road, Leeds).
Geological Association, Mechanics' Institution, Cookridge Street.
Yorkshire Geological and Polytechnic Society, the Museum, Leeds.

Leicester .....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.

Geological Association, Free Library, William Brown Street.

Geological Society, Royal Institution.

Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne Institution of Mining Engineers.

North of England Institute of Mining and Mechanical Engineers.

Newcastle-under-Lyme ..... North Staffordshire Naturalists' Field Club, (W. Wells Bladen, Esq., Stone, Staffordshire).

Norwich .....Norfolk and Norwich Naturalists' Society.

Oxford .....Bodleian Library.

Radcliffe Library.

North Shields....Public Free Library.

Rochdale.....Literary and Scientific Society, 105, Freehold Street.

Southampton ....Hampshire Field Club, Harley Institution.

Stoke-on-Trent ..North Staffordshire Institute of Mining and Mechanical Engineers.

Warwick .....Natural History Society.

Watford, Herts...Herefordshire Natural History Society and Field Club (Daniel Hill, Esq., Hon. Librarian, Herga, Watford, Herts).

Wigan .....Free Library.

Mining School.

II.—SCOTLAND.

Dundee .....Free Library and Museum.

Edinburgh .....Advocates' Library.

Edinburgh Geological Society.

Royal Society.

Royal Physical Society.

Glasgow .....Geological Society.

Natural History Society.

Hamilton .....Mining Institute of Scotland.

III.—IRELAND.

Dublin .....Royal Dublin Society.

The Library, Trinity College.

Belfast .....Natural History Society, the Museum.

IV.—AUSTRALIA.

Adelaide.....Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne .....Geological Society of Australasia, Colonial Mutual Chambers.

Public Library of Victoria.

Australian Mining Standard.

Sydney .....Free Public Library.

Australasian Association for the Advancement of Science, the University.

Royal Society of New South Wales, 37, Elizabeth Street.

Department of Mines.—The Government Geologist.

V.—Canada.

Halifax, Nova Scotia..... Nova Scotian Institute of Science.

Hamilton, Ont. ..Hamilton Association.

Montreal.....Library of Canadian Mining Institute, Room 4, Windsor Hotel, Montreal.

M'Gill University (The Principal).

Ottawa .....Geological Survey of Canada (Director, Museum, Sussex Street, Ottawa).

St. John, N.B. ..Natural History Society of New Brunswick.

Toronto .....Canadian Institute, 58, Richmond Street, E.

VI.—India.

Calcutta .....Geological Survey of India.

VII.—United States.

Baltimore .....The Maryland Geological Survey (The State Geologist, John Hopkins University).

Boston .....Free Library.

Cambridge, Massachusetts ..... Museum of Comparative Zoology, Harvard College.

Chapel Hill, North Carolina..... The Elisha Mitchell Scientific Society.

Chicago .....The Chicago Academy of Science.

Field Columbian Museum, Zool. Series.

Columbus .....Ohio, Geological Survey of. (The State Geologist).

Denver .....Colorado Scientific Society, Denver, Colorado.

Indiana .....Department of Geology and Natural Resources (W. S. Blatchley, Esq., State Geologist).

Illinois .....Illinois Mining Institute, Springfield, Ill.

Field Columbian Museum, Chicago.

Michigan .....Michigan Mining School, Houghton.

Minneapolis ....Geological and Natural History Survey of Minnesota, Bulletin.

Jefferson City, Missouri.... } Missouri Geological Survey.

New York .....American Institute of Mining Engineers, (R. W. Raymond, 99, John Street, New York City).

American Museum of Natural History, Central Park.

Philadelphia ....Academy of Natural Sciences.

Franklin Institute.

Pennsylvania Geological Survey.

American Philosophical Society, 104, S. Fifth Street.

Scranton, Pa ....Editor of "Mines and Minerals."

Washington ....Library of the U.S. Geological Survey.

Smithsonian Institute.

Wisconsin .....Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming .....Historical and Geological Society.

VII.—Foreign Societies.

Berlin .....Deutsche Geologische Gesellschaft.

Gesellschaft für Erdkunde. Wilhelmstrasse, 23, S.W.

Brussels .....Société Royale Malacologique de Belgique.

Buenos Ayres....Officiana Nacional de Commercie.

Caen .....La Société Linnéenne de Normandie.

Christiania.....Royal University of Norway.

Dresden .....Naturwissenschaftliche Gesellschaft Isis.

Halle, A/S.....Verein für Erdkunde.

Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors.....La Commission Gèologique de la Finlande. Dr. J. J. Sederholm, Boulevardsgatan 29.

Iglo, Hungary ..Societé Hongroise de Carpathe.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lausanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Lille .....Société Geologique du Nord.

Mexico .....Sociedad Cientifica "Antonio Alzate."

Naples .....Accademia della Scienza Fisiche e Mathematiche.

Paris .....La Société Gèologique de France.

Paris .....La Société de Spéléologie. 7, Rue des Grands Augustins.

Pisa .....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome .....Reale Academia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Institut des Mines. Comité Géologique.

Stockholm .....Académie Royale Suedoise des Sciences.

Turin .....Académie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 165, Strand, W.C.

Mining Journal, 46, Queen Victoria Street, London.

Colliery Guardian, 49, Essex Street, Strand, London.

Science and Art of Mining, 27, Wallgate, Wigan.

Stone, F. W. Hoyt, 45, Broadway, New York.

LIST OF MEMBERS.

NOVEMBER, 1901.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1884	Ainsworth, John, Walkden, R.S.O., Lancashire.
1884	Aldred, James, Bull Hotel, Ratcliffe.
1897	Allen, Edward, M.E., Willow Bank, Peel Causeway, Bowdon, Cheshire.
1898	Allen, Robert, River Cottage, Lower Broughton, Manchester.
1893	Ashworth, John, C.E., 8, King Street, Manchester. *Member of Council.*
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton.
1895	Atherton, H. Stanley, 7, Brazennose Street, City.
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent.
1897	Baker, Godfrey, Pendlebury, Manchester.
1901	Baldwin, W., Hall Bank, Rochdale.
1893	Bancroft, Robert E , 8, St. James' Square, Manchester.
1900	Banks, Thomas, 60, King Street, Manchester.
1895	Barnes, J., F.G.S., South Cliff House, 301, Great Clowes Higher Broughton. *President. Hon. Auditor.*
1875	Barrett, W. S., J.P., 64, The Albany, Old Hall Street, Liverpool. *Past-President.*
1891	*Bell, Thomas*, J.P., 15, The Valley, Scarborough.

Year of Election.	Names and Addresses.
1897	Bennett, F. F., M.I.E.E., 13, Victoria Buildings, Manchester.
1899	Bennett, Samuel B., 60, Gloucester Road, Urmston.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.
1898	Boden, Peter, Butterworth Hall Colliery, Milnrow, Rochdale.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington.
1886	Bramall, Henry, M.Inst.C.E., Shade House, Pendlebury, Manchester.
1900	Brancker, Richard, 11, Old Hall Street, Liverpool.
1877	*Broeck, Ernest Von den*, 32, Place de l'Industrie, Brussels.
1897	Brooks, the Hon. William, J.P., Crawshaw Hall, Rawtonstall, Manchester.
1900	Burke, Harry, 47, Albion St., Brooks' Bar, Manchester.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, Manchester. *Past-President.*
1897	Caldwell, J. S., Westhoughton, Bolton.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens.
1901	Champ, Henry, c/o. Messrs. S. & J. Watts & Co., Portland Street, City.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1898	Clark, Geo. F., Bickershaw Collieries, Leigh, Lancashire.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1895	Coope, Samuel, Land and Mine Surveyor, Farnworth, Bolton.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, F.G.S., 11, Ironmongers Lane, London.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*

Year of Election.	Names and Addresses.
1900	Davidson, Robert, Clifton Vale House, Clifton, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S., F.S.A. The Owens College, Manchester. *Past-President.*
1900	Deane, Adam, Stopes Colliery, Little Lever, Bolton.
1877	*De Rance*, C. E., F.G.S., 32, Carshalton Road, Blackpool.
1898	Dickinson, Archibald, 13, St. Matthew's Street, Burnley.
1856	Dickinson, Joseph, F.G.S., South Bank, Sandy Lane, Pendleton. *Past-President. Trustee.*
1889	Dobbs, Joseph, Coolbawn House, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan. *Member of Council.*
1898	*Eagle, George, Westminster Buildings, 37, Brown Street, Manchester.
1878	Ellesmere, the Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1897	Ellis, W. T. Wood, M.Inst.M.E., M.S.A., 29, Blackfriars Street, Manchester.
1900	Elce, Abraham, jun., Colliery Manager, 78, Church Street, Dukinfield.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1895	Evans, Robert, Mining Engineer, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, 4, Wellington Terrace, Lichfield Road, Sutton Coldfield.
1891	Fletcher, Arthur, Outwood Collieries, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1868	Fletcher, Thomas, Wheatfield, Bolton-le-Moors.
1873	Garforth, W. E., F.G.S., Snydale Hall, near Pontefract,

Year of Election.	Names and Addresses.
1893	Garside, Edward, B.Sc., Town Hall Chambers, Ashton-under-Lyne.
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., Geological Survey, Jermyn Street, London, S.W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester. *Vice-President.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1892	Grant, Frederick John, Oak Bank, Burnley. *Member of Council.*
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1874	Greenwell, G. C., M.Inst.C.E., F.G.S., Beechfield, Poynton, Cheshire. *Past-President.*
1879	Greenwood, John, c/o The Globe Spinning Company, 1, Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., F.G.S.A., 123, Green Hill, Derby.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, Inspector of Mines in India, 27, Chowringhee Road, Calcutta, India.
1897	Guy, J. G.
1881	Hall. Henry, H.M. Inspector of Mines, Rainhill S.O., Lancashire. *Past-President.*
1898	*Hall, Levi J., Morland House, Birch Vale, near Stockport, (Furness Vale Collieries, Stockport.)
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1877	Harris, George E., M.E., Assam Railway and Trading Co., Limited, Margerita, Assam, India.
1894	Harrison, George B., H.M. Inspector of Mines, 278, Worsley Road, Swinton, Manchester. *Member of Council.*
1892	*Haworth, Denis, Oswaldtwistle Collieries, Accrington.
1894	Hayward, John, Ladyshore Colliery, Little Lever, Bolton.

Year of Election.	Names and Addresses.
1897	Heather, Frank, 47, Mosley Street, Manchester.
1900	Henshaw, A. M., Talk-o'th'-Hill Collieries, Staffordshire.
1889	Higson, Charles H., 106, Eccles Old Road, Pendleton, Manchester.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1900	Hinnell, Leonard H., Civil Engineer, 41, Corporation Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 37, Cross Street, Manchester. *Hon. Treasurer.*
1899	Hollingworth, David,
1895	Holroyd, W. F., F.G.S., 31, Barrfield Road, Pendleton. *Vice-President. Hon. Librarian.*
1897	Howsin, Evelin G., Huntroyd Estate Office, Padiham.
1894	Hughes, Owen, Rose Hill House, Hindley, near Wigan.
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1895	Hutchinson, John William, Bamfurlong Collieries, Wigan.
1887	Jackson, Andrew, Craven Lodge, Rainhill S.O., Lancashire.
1878	Jackson, Charles G., Rookwood, near Chorley.
1898	James, Isaac, Wigan Junction Collieries, Abram, Wigan.
1883	Jobling, Albert, 91, Rectory Road, Burnley.
1883	Jobling, Henry, 91, Rectory Road, Burnley.
1884	Jobling, John, Manager, Cliviger Colliery, Burnley.
1900	Jobson, Henry, Mining Student, Bank Hall Colliery, Burnley.
1882	Johnson, William, Abram Colliery, Wigan.
1887	Kay-Shuttleworth, Sir Ughtred J., Bart., M.P., Gawthorpe Hall, Burnley. *Past-President.*

Year of Election.	Names and Addresses.
1897	Keen, James, Hindley Green, Wigan.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1901	Knight, Henry, Manager, Rose Bridge Ince Hall Collieries, Wigan.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan. *Member of Council.*
1887	*Knowles, Lees, M.A., LL.D., M.P., Westwood, Pendlebury. *Trustee.*
1898	Krauss, John Samuel, B.A., Hodnet, Shropshire.
1898	Landless, Richard, Bank Hall Colliery, Burnley.
1898	Laverick, John H. W., Pye Hill, near Nottingham.
1890	Law, J. Illingworth, Waterfoot, Manchester.
1900	Lawson, A. C., Carrisbrooke House, Osborne Road, Levenshulme.
1899	Leah, Richard, Smedley Road, Cheetham, Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan. *Member of Council.*
1897	Lees, Frederick, The Rookery, Ashford, Bakewell.
1899	Leigh, Oswald B., Westbourne, St. Annes-on-Sea.
1894	Lindsey, Charles R., B.Sc., 509, Edge Lane, Droylsden, Manchester.
1808	Livesey, John, Rose Hill Colliery, Bolton.
1898	Lomax, James, 65, Starcliffe Street, Moses Gate, Bolton.
1887	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Moss Colliery, Ince, near Wigan.
1881	Macalpine, G. W., Parkside, Accrington.
1897	McCallum, Theo. S., C.E., 52, Corporation Street, Manchester.
1901	McKay, William, New Moss Colliery, Audenshaw, Manchester.

Year of Election.	Names and Addresses.
1897	Makepeace, H. R., H.M. Inspector of Mines, Trentham, Stoke-on-Trent.
1891	Marshall, Herbert S., Arnoldsmere, Freshfield.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Member of Council.*
1893	Matthews, E. L., Belvedere Street, Withington Street, Pendleton, Manchester.
1896	Matthews, Thomas, Imperial Iron Works, Belvedere Street, Withington Street, Pendleton, Manchester.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Clifton, Bristol.
1900	Maxwell, Frank, Architect, 41, Corporation Street, City.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham. *Member of Council.*
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Assoc.M.Inst.C.E., Oakwood, Walkden, Bolton. *Vice-President.*
1895	Mort, Arthur, B.Sc., Sharigh, Baluchistan.
1878	Nall, Simon, Newbold, Rochdale.
1898	Naylor, Alfred, Cotes Park Colliery, Alfreton, Derbyshire.
1897	Nelson, William, jun., Clifton and Kearsley Collieries, Clifton, Manchester.
1897	Noar, L. Lamb, The Grove, Lymm.
1900	Ollerenshaw, W., Manager, Denton Colliery, Denton, Manchester.
1888	Oliver, Samuel A., King Street, Wigan.
1891	Orchard, Albert J. A., Whitehouse, Nailstown Colliery, near Leicester.

Year of Election.	Names and Addresses.
1876	Peace, George, Monton Grange, Eccles. *Member of Council.*
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1897	*Pickup, P. W. D., Rishton Colliery, Rishton, nr. Blackburn.
1900	Pickstone, William, 11, Brighton Grove, Rusholme.
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1899	Pilkington, Lawrence, South Garth, Eccles Old Road, Pendleton.
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S., Moss House, King's Road, Rochdale.
1891	Prestwich, Joseph, Elm Bank, 72, Eccles Old Road, Pendleton, Manchester.
1897	Reid, Alexander, Aroofa, Fairy Road, Wrexham.
1900	Rhodes, John R., Gorphwysfa, Prestwich.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton. *Past-President.*
1900	Ridyard, George, M.E., Bruntscar, Westhoughton.
1893	Rigby, John, Highfield, Winsford, Cheshire. *Member of Council.*
1897	Ritson, W. A., 44, Woodlands Street, Cheetham, Manchester.
1889	Robinson, John, Haydock Collieries, St. Helens.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1898	Roscoe, Thomas, Peel Hall Collieries, Little Hulton, Bolton.
1895	Rothwell, Samuel, Silverwell Street, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.

Year of Election.	Names and Addresses.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Past-President.* *Hon. Secretary.*
1888	Scarborough, George Edward, Colliery Manager, Newton and Meadows Collieries, Wigan.
1897	Scholes, Thomas, 25, Crossley Street, Longsight, Oldham.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., 133, Manchester Old Road, Middleton.
1891	Scowcroft, Thomas, J.P., Redthorpe, Bromley Cross, near Bolton.
1899	Selby, John B., Atherton House, Leigh, Lancashire.
1882	Settle, Joel, The Hill, Alsager, Stoke-on-Trent.
1878	Settle, Miles, Rosslymn, Lytham Road, Blackpool.
1889	Settle, William, Brunswick House, Haulgh, Bolton.
1899	Shaw, Alfred, Bersham Colliery, Wrexham.
1884	Shaw, David, Norbury Moor, near Stockport.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1894	Slee, John, Engineer, Earlestown.
1864	*Smethurst, William, F.G.S., Brynmair, Dolgelly, North Wales.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1881	Southworth, Thomas, Hindley Green Collieries, Wigan.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire. *Member of Council.*
1881	Squire, J. B., Assoc.M.Inst.C.E., 20, Victoria Street, Westminster, London, S.W.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Past-President.*

Year of Election.	Names and Addresses.
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1899	Tansley, A. E., Springfield House, Coppull, Chorley.
1899	Tatham, Roger, 51, Oxberry Avenue, Fulham, London, S.W.
1901	Taylor, John, 51, Park Road, Darwen.
1889	Taylor, William, 51, Park Road, Darwen.
1892	Thom, John, Canal Works, Patricroft.
1893	Thompson, F. W., 18, Wood Street, Bolton.
1892	Thompson, James, 248, Chorley Road, Westhoughton, Bolton.
1897	Tickle, James, Ince Hall Collieries, near Wigan.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Argyll Lodge, Higher Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President.*
1898	Tonge, James, Jun., F.G.S., 21, Mawdsley Street, Bolton. *Hon. Secretary.*
1886	*Trafford, Sir Humphrey Francis de, Bart., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Church Street, Leigh, Lancashire.
1892	Turner, William, Wigan Junction Colliery, Abram, near Wigan.
1896	Turner, Robert, Sherdley Collieries, St. Helens (and Jesmond House, St. Helens).
1876	Unsworth, John, Scot Lane Collieries, Wigan.

Year of Election.	Names and Addresses.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.
1888	*Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1897	Walton, Thomas, Habergham Colliery, Burnley.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Brookfield House, Northwich. *Member of Council.*
1880	Watts, William, F.G.S., Underbank Hall, Deepcar, near Sheffield. *Past-President.*
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester. *Vice-President.*
1890	*Whittaker, William*, B.A., F.R.S., F.G.S., Freda, Camden Road, Croydon.
1891	Whitehead, J. J.
1898	Widdowson, J. H., 19, Brazenose Street, Manchester.
1867	*Wild, George*, Albert Street, Bardsley, Ashton-under-Lyne.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, King Street, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Hon. Auditor.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.

Year of Election.	Names and Addresses.
1897	Wood, Percy Lee, Clifton and Kersley Coal Co., Ltd., Clifton, Manchester.
1898	Woodeson, W., 57, Roseneath Road, Urmston.
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

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Members are requested to communicate to the Hon. Secretaries all changes of address, also any omissions, or corrections required in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, November 12th, 1901, in the Society's Rooms, 5, John Dalton Street, Manchester.

The President, Mr. JONATHAN BARNES, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were elected Ordinary Members of the Society, namely:—

Mr. E. KILBURN SCOTT, Electrical Engineer, Clun House, Surrey Street, Strand, London, W.C.

Mr. FREDERICK WILLIAM STOCKS, F.S.I. (Surveyor to the Urban District Council of Middlewich), Princess Street, Knutsford.

Mr. JOSEPH DICKINSON, F.G.S., read the following Paper "On Lead Mining Districts of the North of England and Derbyshire":—

LEAD MINING DISTRICTS OF THE NORTH OF ENGLAND AND DERBYSHIRE.

Reminiscences by Mr. JOSEPH DICKINSON, F.G.S.

CONTENTS.

I. Introduction: outline; old associations, agents, miners, lessors; prosperity, depression; authors quoted.

II. Districts and Strata: description, watersheds, anticlines; summary of strata, characteristics; tests; strata of Alston Moor.

III. Veins and Faults—Discovery of: natural exposures, temporary exposures, ordinary indications, deductions; observations.

IV. Ditto ditto—Ordinary characteristics; resemblances and differences; structure, synonyms, contents, direction, length, breadth, depth, cheeks, hade, throw, intersections and crossings.

V. Ditto ditto and Strata—Origin of: theories, corollaries, anomalies, growth, tithe; observations.

VI. Ditto—Aspects of richness and poorness: speculative; proximity to dissimilar formations, position in the series and depth, kind of strata, kind of alluvial or other surface covering, groups of veins, contents, course or direction, length and breadth, hade, throw, intersections and crossings, the ores.

VII. Ditto—The working: common system, hard and soft ground, blasting, gases, descent and ascent, drainage, exploration, dressing.

VIII. Conclusion: summary and suggestions.

I.—Introduction.

It is well known that mineral ores have been worked in various geological formations, and at both high and low elevations. The lead mining districts of Cumberland, Durham, Northumberland, Westmoreland, and Derbyshire, now about to be noticed, are situated in the carboniferous limestone formation at a medium height above sea level. The landscapes consist mainly of rounded hills, fells, and valleys, with an occasional bluff escarpment, as on Crossfell.

In the northern counties the commencement of working was in ancient times. Royal charters and privileges were granted to miners about 700 years ago; and as to the natives, judging from the cadence, some have Saxon association. The working of the Derbyshire mines dates from the earliest period to which the British records extend.

As to the northern counties, the writer of this monograph has known some of the mines since boyhood. His ancestors resided at Alston, in Cumberland, and were connected with the management and working of the mines; and in addition to them it was his privilege to know others similarly occupied. His school holidays were passed there. Through these connections and natural inclination he then visited many of the under-ground workings, including the Nentforce deep drainage and exploration adit level then being driven. These associations together with after visits link his reminiscences back to near the middle of the 18th century.

Among those early mining friends was his paternal grandfather Mr. John Dickinson of the Manor house, Lowbyer, Alston, who about the year 1770 when a young man began his long and useful career as resident mining agent, called moormaster,of the extensive Royalties of Alston Moor belonging to the Lord's Commissioners of Greenwich Hospital. After him came his eldest son Mr. Thomas

Dickinson who continued the moormastership to near the middle of the 19th century. A change then ensued, Mr. Paul from Cornwall being appointed successor. Collateral with the foregoing were many important personages at the mines; including—Mr. Stagg, followed by Mr. Robert W. Bainbridge at the London Lead Company's Nenthead, Middleton, &c., mines; Mr. William Crawhall and Mr. John Nevin, followed by Mr. Thomas Sopwith and Mr. Thomas J. Bewick at Mr. Beaumont's Allenheads and Coalcleugh mines. Also the Messrs. Little, Wilson, Walton, Mr. Taylor of London, and many others of high standing but too numerous to mention. To Mr. Walton, of Greenends, a public monument, intended originally for his grave, was erected in a conspicuous place in the town of Alston.

During the long continuance of busy work at these northern mines the moormasters were active in supervising the mining affairs both above ground and below ground, and always ready to advise on technical points. The agents and those under them acting in the management, (a select few of whom held philosophic theories on the formation of strata and veins) were mostly diligent practical miners, knowing well how to discover and trace veins, the signs of richness and poorness for ore, and apt in using off-hand tests for distinguishing rocks and minerals.

The working miners as a body were noted as industrious and observant. Those employed at mines away from habitations had to rough it somewhat, as if at newly discovered gold diggings. Locomotion was chiefly on foot, with an occasional ride on the lead carts. Starting early on the Monday mornings in their clogs they clattered from home to the mines, worked through the week, sleeping in the mine workshop or loft above, and returned at the week ends to rest. That rest of many of them was only change from manual to intellectual occupation, thrice at their place

of worship and twice the same day at Sunday school, where in those times some of them obtained their elementary education.

The lessors also were alive to their duties. Their Royalty charges were high, and it may be that the desire of maintaining and extending them acted in stimulating the discovery of fresh veins and the economical working. They accordingly, in 1776, commenced at Alston the Nent force adit level, which, in 1842, was completed to Nenthead.

The combined result from all working harmoniously was, notwithstanding the high Royalties, the mines kept in full operation until after the middle of the nineteenth century.

Since then contrast has come. The average market price of lead has been lower, exploration has slackened, many miners have moved away to where work and better wages are obtainable. Now only an exceptionally rich mine is in full operation; most of the mines being either entirely idle or with very little work going on.

As to the Derbyshire lead mines, the writer is not so well primed generally as on those of the northern counties. He has visited some of them, and from what he knows personally, and from information, he can say that with very few exceptions lead mining in Derbyshire is at present in a depressed state. Many mines are idle, or are only working on a small scale to maintain their customary rights. Among those now open are two old explorations near Castleton; one a fluor spar mine called Blue John, and the other the Speedwell, with an extraordinary cavern, both of which are kept almost solely as show places for visitors.

Going back only a few years, the output of lead ore in Derbyshire in 1858 was 6,277 tons. In 1878 it diminished to 2,090 tons, from which bottom it has since somewhat revived (mainly by the output of one mine), the output in

1900 being 4,395 tons, of which quantity 25 tons were worked opencast.

In the four northern counties in 1900 the production of lead ore was 7,176 tons. Of this Cumberland produced 1,321, Durham 3,849, Northumberland 520, and Westmoreland 1,486 tons, being very great diminutions as compared with olden times. In the three years ended 1768 (as shown by a quotation in Mr. Westgarth Forster's book taken from the moormaster's returns) the average annual output of the Alston moor mines alone was 20,610 bings or 8,244 tons, being more than six times the present production of the whole of Cumberland, and considerably more than the present joint production of the four counties.

The diminution has been general throughout the whole of the United Kingdom. According to the reports of His Majesty's Inspectors of mines, the total production of lead ore in 1900 was only 32,010 tons, whilst during the 10 years ended 1882 it averaged yearly 73,357 tons.

Had the diminished production been confined to isolated places it might be attributed to local mismanagement; but being national, except at a few favoured mines, it may apparently be set down to causes in which this country could not compete. One of the main causes seems to be the import at low prices from foreign silver and other mines where lead is a residual product. Combined they operate seriously against our home mines.

The notes from which this paper is prepared were made by the writer for his own reference. They contain quotations from the experience of others, but these are so far as possible confirmed by his own observation. Among the authorities quoted are the following practical authors:—

Georgii Agricolæ, de re Metallica, 1556, said to be by George Landeman, a medical gentleman.

Mr. John Williams, Mineral Surveyor, Mineral Kingdom, 2nd Edition, 1810. (1st Edition, 1789.)

Mr. Westgarth Forster, Mining Agent, Garrigill Gate, near Alston, Treatise on the Strata from Newcastle-on-Tyne to Crossfell, in Cumberland, with remarks on mineral veins, &c., 2nd Edition, 1821. (1st Edition, 1809.)

Mr. John Farey, senior, Mineral Surveyor, Upper Crown Street, Westminster, Agriculture and Minerals of Derbyshire (Board of Agriculture), Vol. 1, 1811. (Vols. 2 and 3 respectively in 1813 and 1817 are chiefly on agriculture.)

Mr. Thomas Sopwith, M.A., F.R.S., account of the mining districts of Alston Moor. Also, Treatise on Isometrical Drawing, Chapter 1, on mineral plans and surveys, 1834.

Mr. John Leithard, Mining Agent, Practical Observations on Mineral Veins, prepared for the Newcastle-on-Tyne meeting of the British Association, 1838.

Mr. William Bainbridge, F.G.S., Barrister-at-Law. Law of Mines and Minerals, 2nd Edition, 1856.

Mr. William Wallace, Mine Agent, Nenthead, Alston. The laws which regulate the deposition of lead ores in veins, 1861.

Transactions of the Chesterfield and Derbyshire Institute of Mining Engineers, 1880-81.—Mr. Thomas Evans and Mr. A. J. Stokes, H.M. Inspectors of Mines, Mr. E. M. Wass, Mr. Horatio Bradwell, Mr. R. S. Cope, and Lord Edward Cavendish.

Theoretically the minds of poets cannot be known nor must their souls be vexed, but ordinarily practical miners are not comprised by this courtesy, nor are they supposed to be fully qualified for every vocation. Perusal of some of these mining books shows that the authors possessed community of thought and appreciation of literary ability. Quotations are occasionally reproduced as though they were common property, and excessive sensitiveness expressed lest their

language (intelligent enough for their practical readers) should be wanting in elegance, as though they were expected to compete in diction with professional writers and journalists, *e.g.*—

Mr. John Williams, a fluent Welsh miner, hoped that "some good philosopher would think it worth his while to polish his imperfect work." His hope became realised by Mr. James Millar, M.D., F.S.A., of Edinburgh, editing the 2nd Edition.

Mr. Westgarth Forster adds: "I have not used that polished language which distinguishes some elegant authors who embellish with the beauties of composition whatever they describe; but if I have not written the language of elegance, I have at least confined myself to the language of truth."

Mr. John Leithard, a native of and resident at Alston, regrets that "He had not the good fortune to obtain the usual advantages of education, and would perhaps have remained altogether uninstructed as regards literature but for the active and generous aid of the late John Dickinson, Esq., chiefly at a Sunday school which he promoted; and by assisting in the extensive mining surveys by Mr. Joseph Dickinson (of Alston) and Mr. Thomas Sopwith, and being much employed as a mining agent. As regards facts and practical deductions, he claimed no such indulgence, for in respect of them his education has been in the best of all schools—the mine itself."

Mr. William Wallace (whose book begins and ends with a latin quotation, and contains many such quotations throughout, as well as many from poets and philosophers, and mentions the distraction of thought caused by the performance of practical duties) asks for "the indulgence of the highly educated reader, as it has not been his lot to obtain the inestimable boon of a careful literary training,

without which few can attain the art of writing purely and perspicuously."

The other authors and authorities, most of them busy and working enough men in their way, were content to leave themselves to the judgment of their readers.

II.—The Districts and Strata.

The lead mining districts of Cumberland, Durham, Northumberland, Westmoreland, and Derbyshire, although chiefly on ground of medium height above sea level, have a range of hills known as the Pennine chain in the northern counties, and the Grand ridge in Derbyshire. In the northern part the chain, with a summit of 2,892 feet at Crossfell, forms on the north and east the watersheds of the rivers South Tyne, Allen, Wear, and Tees; and on the west, of the Eden. Southwards, the continuation of the chain forms on the east the watersheds of the Swale, Ure or Yore, Wharfe, Aire, and Don; and on the west of the Ribble and Irwell. Further south, in Derbyshire, the ridge, with a summit of 1,881 feet in the Peak, forms the watersheds of the Derwent and its tributaries on the east, and of the Ethrow, &c., on the west.

This range or "backbone," besides forming the main watersheds on the surface, is also a similar anticline for the strata in the same direction as the watersheds. The average dip of the strata, however, being more rapid than the surface of the ground, causes overlying strata and eventually overlying formations to come on as the rivers flow to the dip.

Many of the rivers at first roll down rapidly from the steep fells and hills until reaching the valleys, where the descent becomes less.

The South Tyne, joined by the Allen, each from the carboniferous limestone, crosses to the overlying millstone

grit; and, joined by the North Tyne and other tributaries, flows over the Newcastle-on-Tyne coalfield, entering the North Sea at Tynemouth, where the Magnesian limestone caps the north cliff at Tynemouth Castle. The Wear flows from and over the same formations, including also the Magnesian limestone. The Tees crosses the same formations, and near Middlesbrough enters largely upon the overlying Saliferous formation. The same applies generally to the southern rivers flowing eastwards.

The river Nent, a tributary flowing into the South Tyne at Alston, might off-hand be thought anomalous to the rule of flowing to overlying formations. It is, however, a specially interesting illustration of the law. Near the source the Nent rolls rapidly down from the steep fell, the decline gradually lessening as it proceeds on its course. From the source to the ending the general dip of the strata is in the same direction as that of the river; but, owing to the decline of the surface being steeper than the dip of the strata, higher strata do not come on. In the last three miles, as shown by the Nentforce adit level, the decline of the surface is 126 yards, and the decline or dip of the strata 30 yards in the same direction.

The lead mining districts of Derbyshire extend from Mam Torr hill, near Castleton, in the High Peak division, where at the very old Odin mine bitumen was worked in the shale above the limestone. The lead ore mines are chiefly in the upper limestones and extend southwards to the town of Wirksworth in the Wirksworth division, a distance of about 21 miles; the width of the mining district being from 5 to 10 miles.

The Derwent is the principal collecting river of the county. The river Wye, one of the main tributaries, flows across the mining strata partially in a diagonal direction from the rise to the dip, higher beds coming on as usual and being

succeeded onwards in the Derwent by higher geological formations, similar to what occurs in the northern counties.

The lead mining strata of Derbyshire as compiled by the old miners from their workings and other observations consist of:—

	Yards.
1st Grit rock	120
Limestone Shale, 150 to 170 yards	160
1st or Upper Limestone..	50
1st Toadstone	26
2nd Limestone	50
2nd Toadstone	30
3rd Limestone, in many beds, with some toadstone..	60
3rd Toadstone	30
4th Limestone, in many beds, with some toadstone..	130
Total..	656

The Limestone shale contains occasionally thin beds of limestone, and traces of coal from one quarter to two inches in thickness; also nodules of ironstone and some bitumen, with springs of chalybeate and warm water. The bitumen is varied—hard, soft elastic, and some liquid.

The limestone near the surface is sometimes decomposed into rottenstone. All the beds contain some chance toadstone, notably the 3rd limestone. They also each contain some masses of chert, or dunstone and white chert. The 4th limestone breaks readily and is preferred for lime burning. Between some of the divisional beds of limestone are thin clayey beds, sometimes called wayboards, which separate springs of water. Caves or caverns are numerous, with swallow holes aboveground where water often enters.

The beds of toadstone vary in thickness like ordinary strata.

The lead mines have been nearly all in the 1st, 2nd, and 3rd limestones, chiefly in the upper beds, some of the strong

rich veins being worked out to the surface, as still indicated by an open chasm.

In the northern counties, the old mining section relating chiefly to the lead mining districts of Cumberland, recorded by Mr. Westgarth Forster, shows the total thickness of strata of all kinds from the uppermost to the lowest bed of limestone to be 680 yards. For convenience this thickness or series is divided into two parts, the division being the stratum of whin called the whin sill.

The whin sill is the lowest stratum that crops out in Alston Moor. It is in one bed of variable thickness, averaging about 40 yards, and apparently correlating with the toadstones of Derbyshire. Including the whin sill the upper part of the series, to the top of the highest bed of limestone, is 369 yards. The lower portion of the series is 311 yards in thickness, the outcrop of the beds being on the Melmerby side of Crossfell.

The total thickness of limestone in the two parts of the series is 155 yards. Of this 59 yards are in the upper portion, and 96 yards in the lower portion. In the upper portion there are eleven separate beds, varying in thickness from half a yard to 21 yards, the thickest being called the Great limestone. In the lower portion there are nine separate beds, varying in thickness from a little more than 2 yards to 44 yards each. The thick beds of limestone in both divisions of the series are, as usual, separated by horizontal partings, some clayey and impervious to water.

It is in the upper portion of the series, the same as in Derbyshire, that lead mining has hitherto been mainly successful. The ore has been chiefly found in the limestone beds, but sometimes in other beds, notably the hazels or hard sandstones. The Great limestone has been especially rich. The aggregate produce hitherto has been chiefly from shallow depths, seldom exceeding 200 yards below the surface.

The Great limestone bed, besides its prolific yield of lead ore, is remarkable for containing numerous fossil shells, some of which are fine specimens of this life at the period.

The outcrops of the strata are ordinarily covered with alluvial drift in the valleys, and up to certain elevations; but on high ground devoid of peat-moss, they are often bare or with only their own weatherings.

Aleburn cavern, near Alston, has long been celebrated as a limestone cavern, with a stream of water in it. At places it varies very much in size. When the writer visited it the access was by climbing up a rise in an old lead mine.

The avocation of the miners necessitated their being fairly well versed in the stratification of the districts and the distinguishment of the usual minerals.

Sandstone they divided into four classes:—the thin bedded hard close grained they called girdle beds; next massive but less hard, hazel; next softer and more porous, sandstone; and the coarse grained, millstone grit. Divisional bedding admitting of easy separation they called a good parting, and when soft for cutting into a good holing. Vertical and oblique faces dividing beds into long masses they called backs, slips, or shoots. Other similar but often less important faces dividing the long masses into either prismatical, cubical or rhomboidal figures, were called cutters or end joints. Limestone beds were credited with having their faces and joints more open than those in other strata; those in hard sandstones came next; shale or plate having the fewest and closest.

Nearly all the ores they knew off-hand, also the spars. In this they were helped by the form of the crystals, &c. Galena lead ore was heavy, cubical or steel grained; calc spar, rhomboidal, or in six sided prisms with only three tops; quartz prisms similarly six sided but with each side face replaced in triangular form at the top.

They had also, including the rocks, many ready tests by hardness, fracture, effervescence with acid, change by fire, and wetting for showing capability of polish. Quartz, flint, and iron pyrites, were harder than steel and emitted sparks when struck by it; copper ore, calc spar, and limestone being softer. Massive limestone they could almost know by its rounded or conchoided fracture, confirmation being as with other carbonates by effervescence and calcining.

Their test implement was mainly a pocket knife, aided sometimes with a hammer, a magnifier, a small bottle of nitric acid, and in more expert hands the blowpipe. Percentages and quantities were left to assayers and analysts.

Part of the Mining Section of the Strata, relating chiefly to Alston moor, as recorded by Westgarth Forster, is as follows:—

Local Names.	Thickness. Yds.	Ft.	In.	Total thickness. Yds.	Ft.	In.
Grindstone sill.—*Summit of Crossfell*	8	0	0	8	0	0
Plate.—Shale	11	0	0	19	0	0
Hazel.—*Compact sandstone, moderately hard*	3	0	0	22	0	0
Plate	3	1	0	25	1	0
1st, or Fell top Limestone	1	1	6	26	2	6
Coal	0	0	8	27	0	2
Hazel.—Upper Coal sill	4	0	0	31	0	2
Plate	10	0	0	41	0	2
Hazel.—Whetstone sill	3	0	0	44	0	2
Plate 4, Hazel 4, and Plate 2, 1, 0.	10	1	0	54	1	2
Sandstone slate.—Upper slate sill ..	8	0	0	62	1	2
Plate	2	1	6	64	2	8
Sandstone slate.—Lower slate sill ..	7	0	0	71	2	8
Plate 10, Hazel 3, and Plate 7	20	0	0	91	2	8
Ironstone and thin Coal	1	1	6	93	1	2
Sandstone.—Firestone	11	0	0	104	1	2
Plate 8, Tuft 3, 2; Plate 4, 1; Girdle beds 2, and Plate 4, 1	22	1	0	126	2	2

Local Names.	Thickness. Yds.	Ft.	In.	Total thickness. Yds.	Ft.	In.
Hazel.—Pattinson's sill	4	0	0	130	2	2
Plate	6	0	0	136	2	2
2nd, or Little Limestone	3	0	0	139	2	2
Plate	6	0	0	145	2	2
Coal	0	1	6	146	0	8
High Coal sill	4	0	0	150	0	8
Plate	2	1	6	152	2	2
Coal	0	1	0	153	0	2
Plate 3, 1; Low coal sill 6	9	1	0	162	1	2
3rd, or Great Limestone, Tumblers, Black, and Limestone	21	0	0	183	1	2
Tuft, or Water sill	3	0	0	186	1	2
Plate	7	0	0	193	1	2
4th, or Small Limestone	0	1	6	193	2	8
Quarry Hazel	10	0	0	203	2	8
Plate 11, and Till bed 2, 1, 6	13	1	6	217	1	2
5th, or Four fathom Limestone	8	0	0	225	1	2
Nattriss gill Hazel 6, thin Ceal and Plate 11	17	0	0	242	1	2
6th, or 3 yard Limestone	3	0	0	245	1	2
Six fathom Hazel 12, and Plate 3, 1, 6	15	1	6	260	2	8
7th, or 5 yard Limestone	2	1	6	263	1	2
Slaty Hazel 4, and Plate 6	10	0	0	273	1	2
8th, or Scar Limestone	10	0	0	283	1	2
Plate	1	0	0	284	1	2
Coal	0	0	6	284	1	8
Plates and Hazels.—*Satin stone found here*	11	0	6	295	2	2
9th, or Cockle Shell Limestone	0	2	0	296	1	2
Plate	2	0	0	298	1	2
10th, or Single post Limestone	2	0	0	300	1	2
Plate and Grey beds	20	0	0	320	1	2
11th, or Tyne bottom Limestone	8	0	0	328	1	2
Whetstone bed	1	0	0	329	1	2
Whin sill.—Basaltic Greenstone	40	0	0	369	1	2

The above is the Alston Moor Series.

Local Names.	Thickness. Yds.	Ft.	In.	Total thickness. Yds.	Ft.	In.
Plate and Hazel beds	23	2	6	393	0	8
12th, or Jew Limestone	8	0	0	401	0	8
Plate 2, 1; Slate 5; Plate 1, 1, 6	8	2	6	410	0	2
13th, or Little Limestone	6	0	0	416	0	2
Plate and Grey beds 5, Hazel 17, Plate 8	30	0	0	446	0	2
14th, or Smiddy Limestone	10	1	6	456	1	8
Hazel	4	0	0	460	1	8
15th, Limestone	8	1	6	469	0	2
Plate 1, 1, 6; Hazel 4, Plate 1, 2	7	0	6	476	0	8
16th, or Robinson's Limestone	7	0	0	483	0	8
Hazel 3, and Plate 1	4	0	0	487	0	8
17th, or Rundle or Melmerby Sear Limestone	44	0	0	531	0	8
Plate 4, Freestone 2, Plate and thin Coal 2	8	0	0	539	0	8
18th, Limestone	4	0	0	543	0	8
Freestone 35, Plate beds and Freestone 20	55	0	0	598	0	8
19th, Limestone	2	1	6	600	2	2
Freestone 4, Plate 14	18	0	0	618	2	2
Coal	0	0	7	618	2	9
Plate 43, Freestone 10, Girdle beds 2, 1, 6	55	1	6	674	1	3
20th, Limestone	6	0	0	680	1	3
Freestone						

III.—Mineral Veins and Faults—Discovery of.

It is supposed by some persons that the principal mineral veins and faults are all at some portion of their range open to the surface, and that therefore in well explored districts few, if any, remain undiscovered. Other persons hold that veins may be entirely covered with drift. All, however, are agreed that some of the discovered veins have yet been only partially explored.

The discovery of veins and faults has doubtless occurred in a variety of ways. These are chiefly bare exposure, temporary exposure, searching from ordinary indication, and searching from deduction.

First.—Those exposed, as on the face of cliffs and other bare rock, would be open to practised eyes. If rich they would be worked and developed. If poor they might be tried, and the direction noticed for prospecting on the course.

Second.—Temporary exposures have occurred at times where drift has become removed by floods of water, landslips, or excavations.

These modes of discovery may be passed over as obvious enough without comment.

Third.—Discoveries by searching from ordinary indications, such as the finding of pieces of ore or veinstone, metallic sand, or mineralised water, whether on the ordinary surface of the ground, or in newly turned up land, as in molehills or newly ploughed fields; from springs at the side of the fissures; from alteration of the ordinary crystal or colour of rocks; from discoloured grass, trees, or other vegetation; from differences of temperature of rocks and springs of water.

Fourth.—From deductions, such as from where lightening strikes, and other electrical phenomena, and from hygrometrical and other indications.

These third and fourth indications and deductions necessitating search may be touched upon from some of the points of view.

Amongst the ordinary indications the following may be mentioned. A notable instance of the difference of temperature of springs of water has continued from remote ages at Buxton, in Derbyshire, where warm water with remarkable solvent power issues at 82° Fahrenheit, and within a few

yards of it a spring of cold water of different quality at 52°, the separation between the two springs being a large fault, which at the northern part of the Buxton Crescent formed such a bad foundation as to require long piling. Other more minute differences of temperature are sometimes observable on the surface of the ground, from the melting point of snow, and from the dew point especially early in summer mornings. Alterations of structure, colour, and dip of rock, also mineralised water, &c., near veins and faults are well known. Differences of temperature due to chemical action are also well known to those experienced in mines such as of copper pyrites; and it may readily be conceived that from such action the overlying surface temperature may become affected. The pieces of ore and veinstone found on the surface should, if possible, be distinguished from what may have come from long distance in the drift.

As to the deduction on obscure observations, without furbishing up superstition or mixing faith healing overpowering physical ailment, as attributed to the waters of Holywell and Taff's Well, and to first entry into the moved waters of olden times, it would be unwise to pass by all subtle indications of veins as unworthy of notice. On these points, be it remembered that it is within living memory that spectrum analysis has shown by bars of colour that constituent parts of the earth and of the planets are analogous; and that only recently the similarly marvellous discovery of the Röntgen rays was made, exhibiting subcutaneous foreign contents in the human body.

Beginning with the "divining or dowsing rod," which has possibly been most ridiculed, it has apparently sometimes served the purpose as a cloak for making known in a dramatic manner information otherwise obtained, the real means of the discovery being kept secret. Be this as it may, the oldest book on mining in the writer's possession—

Georgii Agricolæ de re Metallica—a book containing exhaustive and valuable descriptions of metalliferous mining—shows on the first plate a man searching for mineral veins by means of the dowsing rod. The rod is shown as a forked stick like the letter Y. With this the searcher is first shown walking over the ground holding one fork in one hand and the other fork in the other hand, and the but-end pointing down at an angle of about 45° from the horizon. Next, on the same plate the searcher is shown with the but-end of the stick close to the ground, as though it had been drawn down, and near to is a trench being opened on a vein.

It is generally recognised that any person with good eyesight can see equally far as others into stone or wood. Yet indications unobserved by some may be apparent to others. Deposit of hoar frost, for instance, sometimes shows where cross timbers are fixed at the other side of doors and boarding, the ceiling of a room also after long unwashing shows by a different shade the line of each beam above—explainable in the case of the frost by the hydrometric state of the atmosphere, and in the case of the ceiling by relative amount of vibration. Similarly, some earth structures, such as veins and faults may also be indicated.

Subtle currents of electricity have been proved in mineral veins. Lightning also has often been known to strike near the course of known faults and veins. When lightning conductors were less numerous than now, residents in the Irwell valley near the line of the 1000 yard fault between Bolton and Salford avoided being under arches in the vicinity during thunder storms. Even now, with lightning conductors common on nearly every spire and high chimney stack, such strokes occasionally occur near the line. A few years ago the steeple of Christ Church, in Salford, was struck; and recently in the same vicinity a turret on the Victoria arch entrance to Peel Park was perforated; and

soon afterwards a high gable chimney of the new Technical School in Peel Park suffered; the flagstaff on the tower of St. Thomas's Church, Pendleton, near the same line has also been struck. Most of these points are now better protected. Electric currents in underground wires have also at certain times become disarranged in crossing such fissures. This occurred so often where the underground telegraph wires crossed diagonally the great fault separating the Poynton coal field from the New red sandstone that by arrangement the wires were placed above ground. Other similar occurrences could be added.

It is evident, therefore, that clues to hidden veins and faults may be obtained by indirect means, and it may be that for some cause the person thus obtaining the information thinks fit to make the discovery known in some other way. Such information need not therefore be classed as supernatural. Having obtained the clue, further procedure should be in the ordinary way—by boring, trenching, trial shafts, drifts, and where allowable by "hushing" off the drift with water, until the fissure is found in the rock. "He who discovers and brings to light the hidden harvests of the earth, not only promotes his own interests, but he confers a benefit on the whole community."

IV. Veins and Faults. Ordinary Characteristics.

Mineral veins have many features in common with faults, but there are certain differences. The main point of resemblance is in the outline, and that of difference is in the contents. Most of both are longitudinal sloping fissures, and others are flat caverns and wash-outs. Veins of each kind contain veinstone and sometimes ore. Fissure faults usually contain clay, sometimes stone, the flat ones being usually wash-outs with the roof and floor meeting

together. The fissures are generally important barriers against the passage of water and gas.

Description is given under the following headings:—(*a*) The common structure. (*b*) Synonyms. (*c*) Contents. (*d*) Direction. (*e*) Length. (*f*) Breadth. (*g*) Depth. (*h*) Cheeks. (*i*) Hade. (*j*) Throw. (*k*) Intersections and Crossings.

(*a*) THE COMMON STRUCTURE.—The old book on mining, "Agricolæ de re Metallica, 1556," to which the writer has referred, is in Latin. In it the veins are divided into three kinds:—Vena profunda (deep fissures with branches), Vena dilatata (enlarged), Vena cumulatata (heaped up); but, although so termed in the text, they are shown by the diagrams as varying in form, and so blending as to be mainly divisible into longitudinal sloping fissures and cavernous flats.

In the stratified carboniferous limestone districts now being noticed, the veins are chiefly longitudinal fissures with diverging branches called strings, the others being cavernous flats. The fissure veins hade or slope diagonally across the strata; and the flats are usually at a little distance from the sides of the fissure, the two being connected by a narrow fissure called a string; parts of the main fissures and also of the flats occasionally dilate or swell out into large bodies, especially in certain kinds of strata and at intersections with other veins. The faults also are chiefly longitudinal fissures; most of them contain clay, but an occasional one properly called a dyke contains basaltic whin or other stone; the flat faults or wash-outs where roof and floor meet are rare. Cleavages aud divisional planes which intersect the strata are distinct from veins and faults.

In other carboniferous limestone districts, notably the Forest of Dean in Gloucestershire, iron ore occurs almost entirely in cavernous flats called churns, without any accompanying fissure vein or string.

(*b*) SYNONYMS. Veins and faults have various local names. The vein is sometimes termed a lode, rake, reef, flat, churn, pipe, &c. The fault is sometimes termed a dislocation, dyke, flucan, heave, hitch, nip, slip, throw, trouble, want, &c.

How some of these names originated is difficult to trace correctly. The term rake, for instance, is recorded by Mr. Farey as possibly originating from a long-handled rake used for drawing out the ore and stone from the face of workings in veins where, before the use of gunpowder for blasting, fire was used to disintegrate the hard ground. But as fire was similarly used for driving in stone as well as in veins, it is not evident why the rake common to both should apply only to the vein. The term might perhaps quite as readily have originated in Derbyshire from the course of one of the extensive veins westward from Eyam being through two places called High Rake and Low Rake. Or possibly the side fissures common to some longitudinal fissure veins, resembling a rake when mapped on a plan, may be the origin. The rich Mill Close vein, at Darley Dale, in some parts of its course has such side fissures at both sides, like a double-pronged rake.

(*c*.) THE CONTENTS of veins consist commonly of compounds called veinstone, or veinstuff, and sometimes ore. Many veins do not contain any ore; others have a sprinkling or it may be small ribs, the rich ones having sometimes a thickness of many feet. The whole vein is seldom pure ore.

The veinstone or veinstuff consists of stone, rider, spar, and soft mouldable clay. Whether the contents be massive or porous they are usually ranged in laminated form in the longitudinal direction of the vein, but sometimes crosswise in sloping laminæ.

The rider often overlies the other contents, but sometimes it is either at each side or in the middle, dividing the vein into two parts. The structure of rider is mostly compact,

but sometimes porous and speckled, concreted together with a brownish white or grey quartzose substance; the component parts being usually oxide of iron and manganese mixed with spar, &c. It varies in colour and hardness, and is sometimes called mother of lead and other ores. The grey is hardest, brown next, then the black, the red being the softest. It seems to take its name from being commonly found on the top or *riding*.

Interspersed in various parts of the vein are occasional irregular shaped cavities, varying in size from less than an inch to a few feet in width, the interior being often studded with crystals of spar and ore.

A vein containing spar or other veinstone, but devoid of ore, is often called blind or dead

The contents of fissure faults, as previously stated, are usually clay, sometimes stone. These are either in a single-fold layer or in a series of folds. The occasional flat faults, called wants, where the roof and floor meet together without contents, are generally confined to a particular stratum or coal seam.

(*d*) THE DIRECTION of the principal rich fissure veins averages about N. 60° E. and S. 30° W. true meridian. That of the others, called cross veins (usually of a low grade), is at about a right angle or N. 30° W. and S. 60° E., the same as many of the principal faults. Intermediate veins and faults run in various directions.

The N. 60° E. veins true meridian are often called east and west veins, which approaches within 10° or so of the changeing magnetic meridian—changes which have caused some mistakes in plans, but which are usually avoided by having a check surface bearing.

The direction of the east and west veins in Alston Moor is nearly on the level course of the strata, that of the cross veins being nearly with the rise and dip.

Veins running in intermediate directions are (like the cross veins) usually of low grade, but with an occasional exception. One very remarkable intermediate vein in Alston Moor runs from Burnhope seat, where the anticlinal axes divide the sources of the Tyne, Wear, and Tees; thence, in a north-westerly direction, keeping within the watershed of the Tyne, it crosses that river near Tyne Head Smelt Mill, and on to Cashburn, near Cashburn force, a distance of about six miles. It is called the Great Sulphur Vein, the contents being various ores with a little gold, and its breadth at some places about 100 yards. Parallel with this Great Sulphur Vein, at about one mile south-west of it, is a basaltic whin dyke. Ordinarily the intermediate string veins run only short distances, their chief importance being as feeders of ore to main veins.

The innumerable divisional faces or cleavages, known as cleets, slimes, backs, &c., are generally continuous for only short distances. The same applies to the other divisional faces which cross the former main faces. Some of these faces are vertical to the bedding, others are oblique; the effect of intersections being to separate the stratum into cubes, prisms, or oblique blocks, according to the direction and slope of the faces. Few of these faces contain ore.

The direction of the faces in some mines serves the useful purpose of showing roughly which is north and south; and aboveground, when the sun is visible to indicate nearly the time of day—care in both cases being requisite to avoid twists near veins and faults.

(*e*) THE LENGTH of many veins and faults varies very much, the veins being generally shorter than faults. A few strong veins are eight miles long. Some faults are much longer. One fault called the 90 fathom dyke, as shown on maps, ranges from north of Tynemouth in Northumberland, to near Brampton, in Cumberland, a distance of about 50

miles. Some real whin dykes are even longer. The beginning and ending of both veins and faults is often a small fissure, or it may be a series of fissures.

(*f*) THE BREADTH, or width, between the cheeks or sides of veins and faults varies considerably. A vein in soft shale is often a mere facing, but in hard strata such as limstone and sandstone it becomes enlarged to many feet or even yards in thickness.

(*g*) THE DEPTH to which most veins and faults descend is unknown. Some have been found thinning as if about to disappear, but have again enlarged. Others have become too narrow to be thought worth following. Many continue unchanged, or vary only accordingly to change of stratum. Veins of ordinary strength go through the toadstones and the whin sill, but weak veins penetrate only a short distance or become reduced to a thin fissure. The kind of mineral, however, occasionally changes with depth.

An instance of a very rich vein, with five yards breadth of ore, and several feet of ore and spar at the side, at Llangunnog, in North Wales, is described by the authors as disappearing at a bed of black schist, and although diligent search was made for it by skilful miners during several years, not the least trace of it could be found below.

The antithesis to this description of the Llangunnog vein occurs with some small faults which do not rise from underlying to overlying formations, large faults generally rising. Some whin dykes do not invariably throughout their entire course rise to the surface, or into overlying formations.

(*h*) THE CHEEKS, or sides of veins and faults are usually well defined. Sometimes they are grooved or slickensided either longitudinally or up and down as though caused by friction. Careful observation of these groovings shows terminals like fish scales. These scales terminate in reverse directions on opposite cheeks, from which the direction of

the throw is shown; but in thus judging of the direction, care is requisite to observe the scales on the actual cheeks, and not those sometimes appearing on inner folds of the contents.

The impress of these groovings or slickensides remaining so perfect indicates apparently that at the time of the movement the rocks must have been sufficiently indurated to retain the impression.

(*i*) THE HADE or slope of veins and faults in descending through horizontal strata averages about one horizontal to three perpendicular. This hade is very much flatter in soft strata than in hard, it being sometimes at the angle of 45° or one in one in the soft, but nearly perpendicular in the hard strata.

In inclined strata the hade retains the same relation to the bedding, no matter what may be the dip of the strata. It thus happens that in strata dipping in the same direction and at the same rate as the average diagonal slope of the vein across the strata, the vein will be perpendicular to the horizon; and with a steeper dip of the strata the hade of the vein will be anomalous; whilst with the strata dipping in the opposite direction to the hade of the vein, the vein becomes flatter. Exceptions to this rule occur sometimes but they are very rare. Basaltic dykes are often anomalous, being sometimes at right angles to the strata, without any hade.

Metalliferous miners sometimes term the side of the vein which overhangs, the hanger side, and that which is underneath the ledger side.

(*j*) THE THROW or difference in the altitude of correlative strata at opposite sides of fissure veins, and faults varies from a trifle to so much as 1,000 yards. If when viewed from either side the fissure makes an obtuse angle, with the strata upwards it is an upthrow to the opposite side, but the reverse when the angle is acute. The throw is also sometimes

indicated by the trails of strata dragged from the sides into the fissure; and also by the slickensides as stated in the description of the hade.

It has been assumed by some persons that the throw is proportionate to the breadth of the fissure; but as the breadth varies according to the hardness and softness of the strata which the vein is passing through, this assumption must only be accepted with limitations.

Basaltic dykes, as stated, are sometimes without hade; they are also sometimes without throw.

(*k*) INTERSECTIONS AND CROSSINGS of fissure veins and faults occur in longitudinal and altitudinal directions, and occasion displacement of strata in like manner as to the angles, as those relating to ordinary throws. At some intersections one of the fissures, generally the weaker one, terminates. At others, especially when the intersection is at an acute angle followed by a crossing, one fissure sometimes runs in the other for some distance and then emerging at the opposite side resumes its course. Ordinarily when displacement occurs by an intersection the E. and W. vein is thrown off its course.

In horizontal strata a lateral horizontal movement at the side of a fissure would occasion displacement, but not necessarily any throw; whilst in strata dipping at any angle every horizontal movement, unless exactly on the level course line, must occasion throw.

It has been a moot question whether those fissures which shift or those shifted were latest formed. Possibly both were simultaneously formed. It has, however, long been accepted as settled that whatever body of rock has been displaced or thrown the disparities are levelled off on the surface of the ground—the surplusages having been dispersed or removed in some manner. Other enormous thicknesses of rock have also been similarly removed or

"denuded" by some powerful means. Above such removals and the remaining surface generally up to certain elevations is for the most part covered unconformably with drift containing rounded stones, most of which have evidently been conveyed from far away localities.

Strings or thin veins connected with main veins are usually short. The junction of some of these is diagonal, others are, as stated, at a right angle like the prongs of a rake. The flats or cavernous veins at the side of fissure veins are also usually connected together by a string.

V. Origin of Veins and Faults and Strata.

Innumereable theories have been formulated on the origin of veins and faults and also of strata. The hypotheses have comprised—emergement from chaos, growth, orbit of the planetary system—sedimentation, sublimation, chemical affinity, electricity, &c.; with crumpling, dispersion, re-arrangement on change of form—without as yet resulting in any conclusion acceptable to all. A main difficulty is, whence the elements came. After all, things must be accepted as they are. Therefore, this part may be considered superfluous, and be accordingly disposed of briefly.

Of old, it seems, Buffoon thought the earth was a spark separated from the body of the sun. Hutton, that it was a body of ancient date broken up and re-organised by heat, the contents of veins and dykes having been in a state of fusion. Werner, that all having been in a state of solution different classes of rocks formed at different periods, and as the waters were subsiding mineral substances crystallised and veins and faults became formed; then other deposits, with diversity of changes according to the different degrees of durability in resisting waste and decay.

Coming to the recent practical authorities named as to these special mining districts—

Mr. John Leithard, in his mature age following self-teaching, mine-working, and diversified mining engineering, attributed the stratification of rocks and the filling of veins to electricity. His experiments in mines satisfied him that electric currents flowed along and operated in the veins, and his laboratory experiments proved their effect in the formation of strata. The writer knew him well, and was shown by him stratification reformed in glass tubes, a result from rocks of different kinds crushed and worked into a watery solution and subjected to continued electric action. Mr. Were Fox is said to have made similar experiments.

Mr. Farey ascribed most if not all instances as deposits from somewhere, and the removal by some means of vast loads before the arrangement of the surface as now found.

Mr. Williams had no doubt that this planet of ours had relation and former connection with all the other planets of the same system.

At meetings of the Chesterfield Institute of Mining Engineers (Trans. 1880-81) as to the Derbyshire lead mines, Mr. A. J. Stokes believed the deposits of ore were from a combination of circumstances, including from water, sublimation, and electricity; and mentioned, as apparently anomalous, the association of substances of widely varying specific gravities, from sulphide of lead, 7·5, the heaviest, to calc spar, 2·5, the lightest. The Rev. J. Mello in the discussion described the association of certain ores with particular rocks and the hydrothermal, molecular, and sublimation theories, and concluded that the results might be from a combination of causes.

The following are other observations with varied corollaries and anomalies:—

Volcanic injection of ore suggests rich deposits in greenstone beds and whin dykes which seldom occur.

Fossil remains of former fish, reptiles, shells, and plants, most if not all of aqueous habitat at some period of life, occur in various geological formations.

Pseudomorphous bodies fill spaces left by the disappearance of former crystals, such as quartz found in the casts of fluor spar crystals.

During deposition gravity was not apparently in full operation. Some of the heaviest and strongest rocks are found in the lowest formations, but often intermixed with lighter kinds; the heaviest not always at the bottom.

Many rocks are porous, and some nodules contain minerals differing in specific gravity and with cavities, subject to compression.

Subterraneous excavations in soft ground usually diminish rapidly in size, and even in hard rock have been found lessening in long periods.

Some crystals of ore and spar have often been found forming in disused and side workings of mines.

Based on the supposition that ores are in a constant state of growth and increase in the veins, tithe was astutely claimed. In Derbyshire, in the High Peak, a full tenth was claimed, but only 1/19th paid; whilst in Wirksworth, in 1780, the clergyman arranged with some of the mine owners for 1/20th; but, to meet objections raised by others, accepted 1/40th, expensive litigation ensuing in certain parishes on the claim being made.

Others—philosophers and professors—have treated upon the nebulous theory, cooling of the earth and probable ultimate crashing into the sun when velocity decreases, with other hypotheses needless to recapitulate.

Had Buffon's theory of "a spark separated from the sun" been accepted, or as put by Mr. Williams in his book, or as brought by the writer before this Society many years ago, (when some leading members were so severely orthodox

as to consider it out of order with the geological primer)—to the effect that rocks were arranged when the planetary system was becoming matured, and the contortions and drift trails produced when the orbits were being taken—had these been accepted, geology would be relieved of the glacial incubus and similar perplexities.

Spectrum analysis, as previously mentioned, now shows that homogeneous matter obtains in the component parts of our globe and of the other planetary bodies.

Apparently, therefore, the origin of the earth, with the veins, minerals, and faults, is not quite a settled conclusion. Some of the present geological theories require harmonising with geognostic physics. Candid study may bring forth new light. Unanimity may be slow in coming, and weary tracks have yet to be pursued—like a plea in law through the phases of replication, surrejoinder, and rebutter. Meanwhile the miner must continue to deal with things as he finds them, and endeavour to move onward, aiming at truth.

VI. Veins, Aspects of Richness and Poorness.

Gold being the standard, the comparative richness and poorness of veins depends upon the varying circumstances of relative quantity, quality, and value of the ore, cost of production, and transport to and from the mine.

Consequent upon these considerations vein mining has long been looked upon as a speculative investment. The statute of Elizabeth (43 c. 2) recognised it as hazardous by exemption from poor rates (but see Rating of Metalliferous Mines Act, 1874). It has brought fortunes to a few and loss to many. Yet it has a fascination peculiarly its own. Some persons have unbounded faith in the richness of the earth. Hence an opening for the prey of charlatans possessing a smattering of practical knowledge with much

duplicity, as vividly described by Sir Walter Scott in the character of Dousterswivel, in the Antiquary.

Notwithstanding the exposure to such drawbacks, vein mining has a national usefulness completely exempting it from the ordinary gambling element, and with good practical management, free from jobbing, it may constitute a sound paying investment. In pursuance of this view the following notes are intended to record some of the observations on signs of richness and of poorness accompanying fissure veins in these districts.

This part of the subject is treated upon under the following divisions:—(*a*) Proximity to dissimilar formations. (*b*) Position in the series and depth. (*c*) Kind of strata. (*d*) Kind of alluvial or other surface covering. (*e*) Groups of veins. (*f*) The contents. (*g*) The course or direction. (*h*) Length and breadth. (*i*) Hade or slope. (*j*) Throw. (*k*) Intersections and crossings. (*l*) The ores.

(*a*) Proximity to dissimilar Formations, such as granite or slate to carboniferous limestone, is considered by some observers as affecting the general productiveness of a mining district. This may apply to Cornwall and the limestone districts of North Wales, &c., but much less so to the districts now being specially noticed, unless it be at the western side, where, aided by a large downthrow fault, the Upper new red sandstone and Permian appears in the valley of the river Eden.

Some doubt having been expressed as to the actual occurrence of this fault, the writer begs to say that in 1872 he had an opportunity of seeing it at Ousby, E.N.E. of Penrith, under Crossfell, where it was cut through in an exploration for iron ore.

(*b*) Position in the Series and Depth from the Surface.—In these districts the richest mines have been in the upper series and at shallow depths.

The lower series, although containing thick beds of limestone, has proved poor, including a few veins which were rich in the upper series.

In the northern counties the upper series, that is, the upper 369 yards, including the whin sill, has only been penetrated by mines to about 200 yards below the surface. At Grassfield and Brownley Hill Mines, in Nent Valley, the Four-fathom limestone, which was the surface stratum, contained very rich deposits of lead ore; but when the Nent force level was driven underneath and a rise driven up in the vein into the slaty hazel, the vein is said to have been found narrow, with only small pieces of lead ore. At Shildon, also, a mile west of Blanchland, where shallow depths yielded a considerable quantity of lead ore, the celebrated Great Limestone, on being sunk into at 182 yards proved unsuccessful.

On this subject of depth, Mr. John Leithard in his paper states that he knew few practical men who could be induced to explore deeper, however productive the vein was in the upper beds. Mr. Westgarth Forster was not quite so desponding; he considered it probable that strong veins such as the Great sulphur vein, may contain ore in the lower beds.

In Derbyshire, the thickness of the upper series, from the top of the Limestone shale to the bottom of the third Limestone is similar to that in the northern counties, but the depth attained by mines is over 300 yards. One shaft at Overton (the Gregory) is stated at 300, and another (the Ladywash) at Eyam, 306 yards. Possibly some workings have been deeper.

Like forebodings formerly loomed respecting mines in other districts where now at more than double the above-named depths veins continue rich.

Discouragement should not, therefore, be too hastily accepted on meeting with twitches or other slightly unpromising appearance common to veins at all depths.

(*c*) THE KIND OF STRATA seems undoubtedly to influence the quantity of ore. In the northern counties Limestone is the most favourable; next, hard sandstone or Hazel. In Alston Moor the Great limestone has been especially rich. In Plate (shale) the veins are usually very narrow, and seldom carry ore, but it is noticed that if plate is ridered or mineralised the ordinary bearing strata below are generally productive. The whin sill sometimes carries ore, but that seems exceptional.

Ore found in flats at the side of longitudinal veins is generally in limestone. In the northern counties the flats occur, notably in the Great, the Scar, and the Tyne bottom limestones—there being three sets in the Great limestone. The richest flats are generally among a complication of hard veins, and the limestone beds in which they mostly occur are found more susceptible of change and decomposition than others. Ordinarily flats seldom carry ore to the sides or cheeks of the veins, there being mostly a rider and connecting fissure for two yards or so between. Soft sparry veins are seldom productive.

Instead of bearing ore in flats outside the veins, strata sometimes become peculiarly crystalline; and certain limestone beds, notably the Felltop and Little limestones, are for some distance converted into good ironstone. The Scar limestone has sometimes flats containing good ironstone.

In Derbyshire also the most productive mines have been in the limestones—mostly in the upper beds. Veins which proved good in the upper beds have in many situations become poor and ceased to carry ore as descended into, though sometimes the veins with spar still hold their widths. The famed Mill Close mine, at Darley Dale, and the Mill

Dam mines, at Great Hucknall, besides numerous others, have proved rich in the Upper limestone under the Black shale and gritstone. As in the Whin sill of the northern counties, it is exceptional for veins to bear ore in the toadstones unless the veins be unusually strong.

(*d*) THE KIND OF ALLUVIAL OR OTHER SURFACE COVERING, and the particular kind of stratum lying immediately underneath, are not likely to be thought much of as signs of richness or of poorness by persons who in other districts have seen veins carrying ore to the surface of a bare rock. Yet this indication seems to be one of the most reverenced mining traditions in Alston Moor.

The first mention of the kind of cover and adjoining rock affecting the ore contents of a vein that has come under the writer's notice is in a report in 1774 by Mr. John Dickinson, when moormaster. He stated: "It is generally observed that when the surface of the ground through which a vein runs is of clay or moss, and the uppermost sill a limestone, that is a promising object for trial in the limestone; it is also a promising object to try in hazel; but the contrary when the surface is hard benty ground. If the surface be clay or moss, and the hazel uppermost, it is not likely. For we find that in our lead ore mines clay seldom mixes with hazel or soil with limestone." This observatian, it may be noticed, was not set forth as something new, but as what was generally observed. It is also confirmed by the following mining authors:—

In 1811 Mr. Farey, alluding to some rich lead ore deposit in Derbyshire, states that it was covered with clay.

In 1838 Mr. John Leithard states that between different strata there is always some thin soft clayey substance either of a very inferior or non-conductor of electricity.

In 1821 Mr. Westgarth Forster states that the valuable Crossfell Mine carried lead ore up close to the moss.

In 1861 Mr. William Wallace states reasons, in addition to those mentioned, why the cover should affect the subsoil. He considered that, unlike broken or unsound covering, the conserving tendency of clay prevented the descent of fluids below the surface; thus saving the sulphides of lead from being formed into a carbonate, and ultimately dissolved and carried off in solution. He also instances that at Galligill Well and Hudgill Burn mines, on the east side of the river Nent, where vast quantities of lead ore were found in the Great limestone, very thick clay beds form the surface of the country. That at Grassfield and Brownley Hill mines, on the west side of the Nent, the Four Fathom limestone, which is the surface stratum, reposes under a very thick bed of clay, the vein containing very rich deposits of lead ore. Also that at Rodderup Fell mine, where large quantities of lead ore have been produced since it was opened in 1831, the surface of the vein in its direction westward from Slaggy Burn is so thickly covered with clay and other alluvium that the outcropping of the strata cannot be traced except close to the banks of the Blackburn.

It appears that had the moormaster's 1874 report been attended to, the course of the great Nentforce adit or drainage level would have been driven for the first three miles straight to Nentsberry, instead of following the circuit of the Nent, and would have gone under Hudgill Burn, where, in after years, the mines proved exceedingly rich. As it was, however, engineering advantages of lesser cost in sinking air and winding shafts overcame the mining prospects, and the level was driven as Mr. Smeaton, the engineer, projected.

In connection with the surface covering of veins, the assumption by some miners that all veins are open to the surface at some portion of their course, and that such partial exposure is essential to richness, would, if carried out to a

logical deduction, be fatal to further discovery of veins in in any well explored district.

(*e*) GROUPS OF VEINS.—Among a number of parallel veins one at least is generally productive; but two parallel veins near each other are seldom both rich. A vein quite isolated, and without string feeders, unless near an intersection by a fault, is generally poor.

(*f*) THE CONTENTS.—These are considered very promising where brown or black mineral earth like rappee snuff is found, either in cavities in the vein, or lying at the bottom of flats; also rider or metallic oxide, such as of iron, zinc, or manganese, withered and of a reddish brown colour. White or whitish mineral clay, ore coated over with white efflorescence occasioned by decay, and where masses have been washed away leaving irregular honeycombed cavities are also considered good. Quartz spar is usually mixed with ore. A mixture of spars and veinstones of different species is good, calcareous and fluor spars being generally considered the best. A vein with only a narrow rib of ore is generally worth following. Narrow ribs of spars, and ores of similar specific gravity being difficult to separate, are often not worth working unless with suitable dressing apparatus. Hard bold veins without a soft holing are discouraging. A vein divided by coarse crystalline rider is seldom rich at both sides of the division. Rider with spar of a light kind is bad.

(*g*) THE COURSE OR DIRECTION in which veins run in these stratified limestone districts is found to influence their richness. Those ranging east and west are generally best for bearing ore. Those ranging north and south, called cross veins, are ordinarily of low grade except near either intersections and crossings with east and west veins, or where an adjacent east and west vein is broken up and terminating. In other formations elsewhere exceptions occur, as in Ireland,

some of the veins found rich at Knockmahon in County Waterford, and at Allihies in County Cork run north and south.

Clay veins or faults in whatever direction they run seldom carry much ore. They are usually considered to be barren, with a few exceptions. In the Whaley Bridge coalfield, Derbyshire, they contained a little lead ore. In the Northern Counties, at Fallowfield, 2½ miles south-west of Hexham in Northumberland, the great east and west fault which throws in the coalfield at the north side yielded large quantities of lead ore. Like occurrences also occur further north, as though a change was occurring with the latitude.

(*h*) LENGTH AND BREADTH.—Both long and broad veins have often proved rich. In the northern counties the Rampgill east and west vein extended from Nenthead across both the surface watershed, and the anticline of strata to Coalcleugh, a distance of about eight miles, the thickness of lead ore in it being at some parts 12 feet. The Great Sulphur Vein, the course of which is intermediate, has been traced fully six miles, and is at some parts 300 feet in width, consisting mainly of quartz, iron pyrites, copper pyrites, and a small percentage of gold. The exploration of this extraordinary vein has not yet been such as its length, breadth, and contents would suggest as desirable.

In Derbyshire the Great Hucklow and Eyam Edge Veins extend seven or eight miles westward from the town of Eyham towards Peak Forest, on which range, either in the vein or in side shoots and pipes, about 20 mines have been worked. The Mill Close Vein has been followed for several miles to Darley Dale, the width in the present mine extending to 30 feet, besides numerous side shoots of ore, some extending 80 yards from the vein. The workings are

in the upper limestone, immediately underneath the limestone shale. In addition to these, other veins of great width, some of them soft, have proved rich.

(*i*) HADE OR SLOPE.—Where the hade is either nearly perpendicular or very flat, consequent upon the strata having a steep dip in the same direction as the hade, veins are often less metalliferous than with the normal hade.

Notable exceptions occur in unstratified rocks. For instance, in County Wicklow, the course of the Great Ovoca Vein at Ballymurtagh, west of the cross vein, was exceptionally flat, dipping about 1 in 2, that being the dip of the cleavage in which it forms a parallel layer.

(*j*) THE THROW.—When this is so little as to leave the same stratum in the opposite cheeks of the vein, it is considered favourable; but when the throw is so great as to place different kinds of strata opposite, it is considered unfavourable.

(*k*) INTERSECTION AND CROSSING OF VEINS.—Where two veins intersect each other, whether the intersection be downwards consequent upon different hades, or longitudinally consequent upon different courses, they are generally productive about the point of junction. Instances have been observed, however, where, at the intersection of a strong poor vein with a less strong rich vein, both have become poor. Ordinarily all intersections of veins are favourable, whether it be by veins or faults, and sometimes by a whin dyke. Strings or short side veins joining usually feed a vein with ore.

(*l*) THE ORES found in these veins are chiefly lead and zinc, with a variety of others in small quantities; namely, copper, iron, manganese, &c., and in the great sulphur vein at Alston Moor, as mentioned, a little gold. Various spars have also been worked, and in Derbyshire some bitumen.

The lead ore is usually ordinary galena, of a blue colour. It varies a little in specific gravity from about 7·6 to 7·8. The ordinary yield of lead varies according to the dressing of the ore, say from 65 to 80 per cent. or a little more. The average yield of silver from the northern counties lead is put at five ounces to the ton of lead; that from the steel grained ore being much richer than that from the cubical ore. The yield of silver from the Derbyshire ore is so small as to be often not worth separating. The other exceptional kinds of lead ore found are brown, green, white, and yellowish brown. Native lead has been spoken of, but the specimens shown are very rare, and are shrewdly supposed to have come from old smelting hearths at the mines.

The zinc ore is chiefly blende. The total produce of zinc ores in the British Isles according to the returns for 1900 was 24,675 tons. Of this 10,059 tons were produced in the four northern counties, 557 in Derbyshire, and the rest in other counties.

Besides the foregoing description of noticed aspects of richness and poorness of veins, probably others may have been observed, and might be usefully added.

VII. Veins.—The Working.

The general system of working metalliferous mines does not seem much changed from what is occasionally met with in old mines, or from what was so fully described by Agricola, in 1556 The improvements have been in having openings sufficiently in advance to admit of breasting forward, with the ore and vein stuff dropping, or being cast down, instead of being lifted from the sole; also blasting with explosives instead of decripitating by fire; and in the dressing of ores. Full details of the working processes have, however, been so finely described by many able practical

authors that this part of the subject need be only very briefly reviewed here. The review is under the following headings:—Exploring.—Ore when discovered.—Cost.—Descent and ascent of shafts.—Gases.—Adits.—Dressing.

The EXPLORING of a fissure vein is by driving into it, ordinarily this is done by either a level or a shaft. If it be by a level, the driving is commenced either in the vein or by a drift or adit to the vein; and if it be by a shaft, it is by sinking either in the vein sloping with whatever hade there may be, or by sinking plumb and driving cross cuts to the vein. Whichever method be adopted levels are driven in the vein, ventilation being kept up to the faces by pipe or brattice until a thoroughfare for the current is obtained, power being used to move the air when required.

Where two or more levels are driven in the same direction, but at different randoms or depths in the vein, communications are made between them at suitable distances apart. These communications when sunk downwards are called sumps or winzes, and when worked upwards are called rises. But whether made by sinking or rising they leave dangerous openings at the top when unprotected. Hence the pleasantry of Mr. Sopwith's sketch showing a visitor falling headlong down whilst the miner-guide is following along the level giving his too late caution, "Taake care yo dinna faw doon t' rise, for its rather unhandy kinda."

In many parts of the districts now being noticed deep valleys and high hills have specially favoured opening by drifts or adits, pumping being only resorted to when unavoidable. These openings and the levels in the vein are usually driven about 6 feet high by 3½ feet wide, so as to admit of being conveniently travelled, and of horse traction when required. The depth between the levels varies according to facilities for drifts from the surface; but deeper levels are usually at some fixed distance apart, say 20 yards or so,

as considered suitable for proving and working. Each level is known by a specific name, sometimes that of the locality or of the principal miner who drove it, or by number below the adit. The face of each level is called the forehead—hence the further pleasantry when the visitor, after recovery from his fall down the rise, meeting the old miner-guide and inquiring what he was doing now, received the reply, "woor bean bouring a hoyle i' Jack Thompson's forehead."

ORE WHEN DISCOVERED is worked out, the rate of working being usually regulated so as to maintain an average and keep the dressers steadily employed. If there be a lower level the working of the ore is done by breasting forward, the material falling or being cast down. As the excavation increases in area the spaces are usually filled with rubbish for support and to save haulage, strong supports for the material to rest upon being fixed where openings are required underneath. In some districts this kind of working is called stooping or stoping.

Sometimes where ore continues for long distances, pillars or stoops of ore have to be left, that is when the vein is very wide and the ground on the move. If the ore in these pillars will pay for the getting under such circumstances, a side level is driven in the solid ground of the ledger or under side of the vein, and through this separation two or three yards in thickness cross cuts are driven and the pillars worked out.

THE COST OF DRIVING varies considerably according to the kind of ground. Consequently when there is a choice, that which is easiest to drive in and likely to stand is preferred.

Formerly hard rock was softened or disintegrated by burning fires of wood against it; rock of intermediate hardness being sometimes acted upon by changing the

direction of the air current. It is recorded also that when slickensides were found to decripitate on being struck they were punctured to assist driving. Such adjuncts have now almost passed into oblivion, being superseded by improved drilling and blasting.

The special precautions taken in driving through soft heaving ground are minutely described by Mr. Williams in his 1810 book; and they are repeated by Mr. Westgarth Forster. Summarised, they consist of: In horizontal work a sole timber is placed, and upon it are set two side props with a lintel on the top, forming a square. Over the lintel and behind each side prop are driven sharp-pointed stakes, to secure the roof and sides; and when driven far enough to form a protected space within, a similar square is set at the face, and so on. In sinking shafts the stakes or piles are modified accordingly, and likewise for drivings upwards. Since then iron bars have sometimes been used instead of wooden stakes, and other improvements introduced.

THE DESCENT AND ASCENT OF SHAFTS was formerly almost entirely by ladders or by cross bars, part of the shaft being usually boarded off or otherwise separated when the same shaft was used for winding materials. In deep shafts such climbing is now seldom practised, except that in pumping shafts for convenience of seeing to the pumps ladders are still used. The ordinary winding of persons is now either in cages, or by the man-engine with platforms on one or two rods, like pump rods moving up and down, which for metalliferous mines with numerous landing places are found especially useful.

Climbing in the communications between levels is still often found to be most convenient by either ladders or cross bars, a separate communication being reserved for materials when available. For provisional purposes when one

communication has to be used for both materials and persons, footholds and ledges are cut in the sides and a chain hung for climbing up hand over hand. This serves temporarily for an able-bodied person, any one suffering from injury being handed down as carefully as possible by others.

Gases of different kinds are met with in the mines. They consist of blackdamp, which in certain mixtures extinguishes lights, and when very little stronger suffocates; whitedamp, in which, in certain mixtures, lights burn but life fails, this gas usually follows combustion and blasting where the ventilation is slack; also occasionally firedamp, which shows a blue cap on the flames, and when strong enough extinguishes both lights and life, certain mixtures with air being explosive.

Adits, or free drainage levels to save pumping, have cost large amounts of money, but have generally recouped the cost with a large accession of interest.

In the northern counties an adit (often serving as a drawing level) has taken the top water from nearly every mine; and underneath are sometimes deep adits serving several mines. In Derbyshire it is similar, but with perhaps more deep adits, or soughs as there called.

The principal deep adits in the northern counties are:—the Nentforce level in Alston Moor, Cumberland; and those at Allenheads, one at Coalcleugh, another at Haugh main, and the deep adit in West Allendale, Northumberland. The Nentforce level is 4½ miles in length from Alston to Nenthead. It enters with the scar limestone as the roof, near the bottom of Nentforce waterfall, in the valley of the river Nent. For the first three miles the course is in angular lengths, following the circuit of the river to Nentsberry, where it attains the depth of 126 yards. To this point the adit is a boat level with four feet of water, the 1½ miles beyond being without boats. This latter portion

is also at about 30 yards less depth from the surface—the change of random having apparently been occasioned by the boat level gradually entering lower strata and the near approach of the Tyne bottom limestone, in which it would have been costly to drive. The level, as set forth on a tablet at the mouth, was designed by Mr. John Smeaton, C.E., commenced in 1776, completed in 1842, the execution being by order of the Commissioners of Greenwich Hospital, and the cost £81,000.

At Allenheads, the Haugh main adit and the Coalcleugh adit were begun about 1684, when the mines were worked by Sir William Blackett. The later deep adit driven to some of the mines when worked by W. B. Beaumont, Esq., was designed by Mr. Thomas Sopwith and carried out by him and Mr. Thomas J. Bewick.

In Derbyshire 18 principal adits to lead mines (being exclusive of those to collieries) are described by Mr. Farey. Of these the most important are:—

1. Critch, from Fritchley, east of town, length two miles.
2. Cromford, S.S.W. of town, two miles in length, cost £30,000, much warm water was met with.
3. Hannage, from Millhouses, S. of and under Wirksworth town, length 1¼ miles.
4. Hillcar, from Darley to Yolgrove, length three miles, cost £50,000, boats were used in it.
5. Meerbrook, E.N.E. of Wirksworth, length 1½ miles, cost more than £45,000, boats were used.
6. Stoke, from the Derwent, length two miles, cost £35,000.
7. Wakebridge, from the Derwent, N.W. of Crich, length ⅔ mile.
8. Watergroove, N.W. of Wardlow, length, one mile.
9. Yate Stoop, from the Derwent, N.E. of Winster, length 2¼ miles, cost £30,000, it was 20 years in driving.

Many of the Derbyshire mines have been worked down to the free drainage adits. Some others at great cost for engine power have been worked deeper, a few such being still at work. Others, as stated, have struggled on, using hand pumps, whimseys, waterwheels, and occasionally underground hydraulic and steam engines. In the 100 yard shaft, at Mill Close Mine, Darley Dale, one surface steam engine, with 16 inch pumps, and seven feet stroke was used, and afterwards supplemented by another with 24 inch pumps and nine feet stroke. At Mill Dam Mines, Great Hucklow, with a main shaft 150 yards in depth, where the water being required for dressing the ore is pumped to the surface.

It seems obvious, therefore, that many of the Derbyshire mines are below the free drainage limit, and will require either very powerful pumping engines or deeper adits. At the same time water will be required on the surface for dressing purposes.

Chiefly in relation to this drainage question, the following opinions were given before the Chesterfield Institute of Mining Engineers in 1880 :—

Mr. Thomas Evans, then Her Majesty's Inspector of Mines of the Derbyshire district said :—"Upon the general question of lead mining in Derbyshire that was, generally speaking, a thing of the past. With but few exceptions, there was scarcely any mining left, and unless a large amount of capital was brought into the district, and the mines were regenerated, mining must gradually die away. It must be by expenditure of capital."

Mr. Thomas J. Bewick said he noticed either want of mineral or of exploratory works.

Mr. R. G. Cope, of Chesterfield, said: The water should be taken off at a lower level, otherwise the old trade of the miner is passing away.

Lord Edward Cavendish (who at the time mentioned took a foremost part in the Institute) said he "feared the stoppage of the mines had been caused by the simple question of cost and demand; the requirements of the country had been met from other districts and countries at such a rate that Derbyshire could not compete—but that when the demand increased the supply would be forthcoming."

THE DRESSING OF THE ORES has been done mainly at the mines. Much of the ore is mixed with other substances, from which it has to be separated. The dressing which it undergoes is not, however, one of the essential points of this paper except that the difference between profit and loss of a mine may depend upon the advantageous or disadvantageous manner in which it is done. Suffice it to say that ordinarily the mixture as it comes out of the mine is either all taken to be crushed, or the pure parts are first so far as practicable separated by hand—flat hammers called buckers being used for breaking off dross, the persons using them having occasionally pieces of iron tube like thimbles but open at the end to protect the fingers. Large pieces of ore separated by hand are broken into proper sizes for smelting. The crushed ore is washed with a current of water upon an inclined grate, where it is stirred about, the small ore with some mixture passing through into a receptacle. This, together with that left on the grate, being reduced to certain sizes by machinery, is separated (buddled) by jigging, dolly tubs, vanners, &c., the escaping slime flowing into pits for deposit. Many dressing improvements have been made in recent years, and are very ingenious. In separating ores of similar specific gravity where gravitation by water has failed, air at gradually decreasing velocity in an expanding tube has been used.

VIII. Conclusion.

Looking back upon this lead mining it seems evident that the operations during long ages have been very extensive. In the northern counties most of the likely localities have been well searched, and the discovered rich veins worked; and in Derbyshire under the ancient mining privileges portions of the surface have been made waste by the prospecting, and the veins ransacked down to certain depths. The operations in both districts have been chiefly in the upper series of the limestone.

It is not conceivable that in either district every vein in the upper series can have been discovered and sufficiently explored. In the northern counties some known veins have been but little cut into, and as to the lower series where it lies underneath the upper series it is intact. More proving may have been done in Derbyshire, but even there after the struggling on against water it seems that veins with ore in the bottom workings have been inundated.

In both districts the so-called deep workings have been few, and even the greatest depth yet attained is shallow in comparison with the depths reached in other counties where former dismal forebodings of ore ceasing with depth have now been disproved. About 300 years ago the lead mines of Alston moor when at shallower depths were said to be worked out, yet afterwards they continued to provide unprecedented employment and to produce increased richness until the middle of the 19th century.

It may be that only a few mines have proved prizes to the adventurers, and that on the average of all the mines there has been loss. Many important changes have, however, happened recently such as—Improved drills for driving, explosives for blasting, and apparatus for dressing,

but they are as yet only partially adopted. In those mines where the lead ore is associated with zinc ore the recently improved treatment of the zinc ore will propitiate the working of both ores. Under this combination of improved circumstances, renewed stimulus should be looked for in home lead mining.

The subject having been treated upon by so many able authors some apology may be expected from the writer for presuming to offer reminiscences, part of which have been anticipated. He has approached the points deferentially, but he finds extenuation enough in endeavouring to the best of his ability to preserve for use when times mend some of the principal approved experiences. His view is that—with only a few of the mines in full operation, many being either entirely idle or with little exploration, having the remnants of former richness picked out and old waste heaps redressed—most of the experienced miners gone, either 'over to the majority' or to seek a livelihood elsewhere—lead-mining science not yet a certainty—and the opportunities for observation few—every endeavour to resuscitate practical work should be welcome.

Without limiting other measures for this object, the writer begs leave to venture the following as points worthy of consideration:—The driving of more, and deeper, free drainage adits in carefully-selected localities; the increased use of modern drills and high explosives for working, of boring rods where suitable instead of drifts for preliminary proving; of vanning frames and other improved apparatus for dressing the ores; also of chemical test of the slime twice daily to avoid waste of the ore. Lastly, every underground exploration to be visited sufficiently often by a responsible person, acting in the management, to notice every indication before it may be defaced.

The PRESIDENT: Mr. Dickinson has read a most interesting paper—certainly a very long one. I think it might have been conveniently divided into two parts. But before any discussion takes place I shall propose a vote of thanks to Mr. Dickinson for his paper.

Mr. JAMES TONGE, F.G.S.: I heartily second this vote of thanks to Mr. Dickinson. I think it well for this Society that he has its interests so much at heart and that he has been willing to devote the time and labour necessary to the production of a paper like this we have had to-day, in which we have the experiences he has gathered in the course of a long life. He could not possibly have bestowed so much time upon this work if it had not been a real labour of love to him. In an experience of 49 years, I have necessarily come across a considerable number of the points he has mentioned, and had to deal with several, some of which I should like to speak about but time will not permit.

The resolution was adopted with acclamation.

The PRESIDENT: I am sure we are all very deeply indebted to Mr. Dickinson, and scientific investigators generally will be when the paper is printed, as I feel sure it will be, and that it will be a very valuable addition to the Transactions of the Society. The paper will be received with gratitude, not only by historians and scientists, but by geologists generally. As a collection of facts it is simply astonishing, and I think we are greatly indebted to Mr. Dickinson for placing them before us in such an intelligent manner. I had begun to fear he was about to give us no opportunity for making any critical remarks on his paper, because for a long time he gave us nothing but facts bearing on mines, their faults, veins, &c., but when he began to theorise, and was bold enough to make a statement that at the beginning of

the twentieth century geologists do not know, or do not understand stratification, the case was changed. I say he is very bold to make such a statement, and I can scarcely take him *au serieux*, as the French people say. I think every modern geologist is agreed that he understands something about stratification, and something of a very definite character. Observation will show and will teach us how it is brought about. The Ship Canal people will have a very lively recollection of how stratification is formed in the canal, because the Irwell has been so much in flood that it has carried down many thousands of tons of material. This forenoon the lower portion of the river had risen eight feet up to one o'clock. Now when water thus carries material—and it has been doing this all through the geological periods since the first change began on the surface of the earth—when water, I say, carries down material it simply deposits it. Thus one layer is formed, another flood comes and we have another layer, which in time becomes hardened and produces strata. It is so simple that it is difficult to take Mr. Dickinson seriously when he says that stratification is not understood. It is one of the clearest things, to my mind and to the minds of most modern geologists, how stratification has taken place. What is taking place to-day is the same as it has been in past ages.

Mr. G. B. Harrison, H.M.I.M.: I have listened to a great deal of the paper with very great interest. I am familiar with some lead mines in Co. Durham, and having studied metal mining along with coal mining, I have heard the paper with great interest. I feel we are much indebted to Mr. Dickinson for the able manner in which, out of his long experience, he has put so many facts before us. I add my quota of thanks to him with great sincerity.

Mr. DICKINSON: I am much obliged by your vote of thanks. After having detained you so long I am not going to detain you much longer. You, Mr. President, have set forth the adverse part of your views chiefly on one point, that is on Part V., as to the origin of veins, faults, and strata, being the part to which I have attached least importance. I there endeavour to formulate briefly the hypotheses held by the practical miners there named, and my views thereon. I have not any change to make.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, December 10th, 1901, in the Society's Rooms, 5, John Dalton Street.

The President, Mr. JONATHAN BARNES, F.G.S., in the Chair.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were elected Ordinary Members of the Society:—

Mr. C. CHAPMAN, Artesian Well Engineer, 293, Liverpool Road, Salford.

Mr. ABRAHAM FLATTERS, 16, Church Road, Longsight.

The following paper on "The Coal Measures in the Parishes of Prestwich and Bury, illustrated by a cross section between Ringley and Bury," was read by Mr. WILLIAM PICKSTONE:—

ON SECTIONS OF THE SOUTH LANCASHIRE COAL FIELD IN THE TOWNSHIP OF PILKINGTON AND THE PARISH OF BURY.

By Mr. William Pickstone.

It was my intention to have given an up-to-date section of the coalfield to which my paper calls attention, but for reasons that are mostly purely commercial I am unable to do so as fully as I had hoped.

Mr. John Hirst, Mr. Statters' Colliery Surveyor, has kindly not only given me a part cross section of the district, but he has also written some notes thereon which will form a part of my communication to the Society. The section, geologically, from Ringley in the west to Bury in the east, is to me a most interesting one, seeing that it has within its limits a series of faults which, in places, bring in all the seams of coal of the Lancashire field—seeing also that my knowledge of it cost me some £70,000. West of the great fault, all the upper and some of the underlying seams have disappeared, the celebrated Trencherbone being the outcrop seam. It was worked sixty or more years ago by Knowles & Stott by a down-brow on the dip of the coal.

Across the big fault the New Red Cover is in evidence, and as a consequence the Worsley four-feet mine, which is cut at 140 or 150 yards from the surface, but not much worked, is not now being worked, I think. This section is several hundred yards wide from west to east, and as the New Red Sandstone runs on for miles to Manchester, and for miles again south of Manchester, apparently without any serious break, it may be looked upon as a large virgin coalfield. The next section, east, has long been and is still worked at the Outwood Collieries, and it is without doubt a good section, and has in it

most, if not all, the workable seams below the Worsley four-feet mine, but that particular seam has disappeared from the section. East of that is another section in which a down-throw fault of 500 yards brings in the Worsley four-feet mine again. This mine crops out between the railway and the river, where there are distinct traces of workings at some early time of which there is no record. The dip of the coal is steep. It has been proved to be a comparatively small field, and what may be a feature not common, it narrows from the surface downwards, so as to make it seem probable that it is simply a wedge driven down into the two sections that lie west and east of it.

It was proved in this mine that faults existed in the deeper strata that are not found in the strata above them. It would therefore seem that, whatever the proximate causes of these faults may have been, that they were at work while the work of deposition was still in progress. I apprehend that shrinkage was at work during the whole coal formation ages, but was not so active as it afterwards became.

The next section is brought in by an up-throw fault (150 yards). Coal in it has been worked for many years at the Stand Lane and Cawdaw Pits. In it are found most of the seams of the South Lancashire coalfield, from the Ash Clough downwards. So far as proved they are of a fair average quality, but the section is considerably broken up by cross faults. On its eastern boundary is a fault usually called the Stand Lane fault, which reverses the dip. The extent of it has not been proved; it has been attempted, however. The ground was found to be very broken and difficult. My own impression is that it is a great up-throw, and that from this point to the eastern outcrop at Bury not much commercially workable coal, on the basis of recent values, will be found. There is coal, of course, a considerable area of it, and if it should come

to pass that when the good coal is finished up there is still a demand for the article, a practically unworked field may be here available.

At Bury, I opened a colliery in the sixties. A small venture only. One seam only was opened of four feet. The quality was not good enough to please those who tried it, and at 4s. 6d. or 5s. at the pit's mouth for through and through coal, each ton lost money. Money into four figures was lost, but some experience was gained by the venture. It was found that, by a fault or faults to the east of these workings, the dip in the strata had been reversed under the town of Bury.

I have said that this piece of country was, geologically, interesting. We have three to four miles of cross country cut into strips by some action in nature. Some of the faults are *up*-throws, and some *down*-throws. Query—Are not all faults, in fact, up-throws? And is it not because of this up-throwing of the strata that we have any workable coal at all? What depth of strata was piled originally on top of the New Red Sandstone? We may guess it—possibly miles. Where would our coal have been but for the tilting or up-throwing of the strata, and the forces of denudation? We are not usually thankful for shrinkage, but if it be true, as some geologists assert, that these fortunate changes of the earth's crust are due to tilting, &c.; the sometimes dreaded word is not always of dreaded import and evil tendency. I apprehend that both shrinkage and denudation were at work during the whole coal deposit ages, but that they were less active in that period than they afterwards became. I sometimes try to make out the beginnings of things as to our coal formations. How, after the two very distinct and prolonged periods of the earlier depositions—the mountain limestone, and the sandstone beds that overlie them, the former representing great sea

stillness, and the latter the reverse—there came that remarkable period of activity in the vegetable kingdom that gave us our coal measures; when the land claimed its share in giving, aided by sunshine and moisture, an important contribution for the future benefit of mankind—I note the youthful hesitancy in the development of the new conditions as they are seen in the two gannister seams, and how the new life became more vigorous as it developed. The Arley, Cannel, Doe, and Trencherbone mines, rich and clean in quality, certifying for calm and sunshine in the elements, especially away from the riverine areas, as in the Wigan district, and how, gradually, a less pure series of deposit took place, and a less vigorous vegetation, until so far as workable seams are concerned, and after a very long interregnum, the Worsley four-feet was produced—preceded as it was and followed as it was by spasmodic efforts to go on with the useful work, as is seen in the numerous thin seams that are found between the Ash Clough and the final extinguishment of coal making.

What a change was that which is certified by the subsequent deposition of sand that has given us the thick cover of the New Red Sandstone above our coal deposits. The carefully recorded section of the sinking at Patricroft, left to us by the Lancasters, show what a large number of small efforts to form beds of the precious mineral were made, especially when the end was approaching. Each little streak, however small, was a result of forestal conditions and of a flora that was suited to the particular purpose of producing beds of coal—not from the timber I think, if indeed the trees of those forests had any timber in them—but from the fruit. And then I wonder whether we have now, anywhere, such rapid growth as would produce the enormous beds of matter that are represented by even a six or seven feet seam. I fish up for comparison facts about rapid growing

that have come before me. Take, for instance, that of the bamboo which throws up a stem of three to four inches in diameter five or six feet in a week; and that of the aloe, which, starting from a comparatively small plant, throws up a flowering stem, in a season, of four inches diameter, to a height of twenty feet or more, a stem that weighs much more than the plant, and which is topped with scores and scores of large seed pods, and then I conclude that a vegetation of wonderful growth and of wonderful fruitage may be assumed. On this assumption our coal measures stand as preserved fruit—preserved when all the elements fed vegetation vigorously—fed flora rather than fauna. How wide stretching those forests were is certified by existing coalfields, but these, as far as Europe is concerned, are only a tithe probably of what they were at the end of the coal producing times.

As to the differing qualities of beds of coal, and differences of quality of the same seam in districts quite near to each other—in the district, in fact, we are more especially considering—it is no doubt due to the proximity of great rivers which in flood times overflowed the forests, lodging much earthy matter, with consequent injury to the quality of the coal.

How many times the crust of the earth went under the sea during the coal making ages, and for how long, at times, the waters prevailed, as indicated by the depth and variety of the strata that are found between one bed of coal and the next one may be an interesting study for twentieth century students of science, especially for such of them as may not need to work for a living. The facts of what occurred are more easy of solution than the time it took to produce them.

Looking at the general change in the quality of the coal as we approach to the millstone grit outcrop to the north and east of Bury, I venture to express the opinion that the great

river, that came from the Alpine Continent of which this Island formed part which emptied itself into an earlier Northern Sea, wended its way in a direction on the lines of the backbone of central England's upheaval.

The following notes on the subject have been supplied to me by Mr. John Hirst:—

The accompanying Vertical Section illustrates the mines through the Irwell Valley Fault, running in a north-easterly direction from a point south of Wet Earth Colliery across the fault and into the hamlet of Outwood. On the south side of the Irwell Valley Fault the mines dip at the rate of 1 in $3\frac{1}{3}$, and on the north side from 1 in 2 to 1 in $2\frac{1}{2}$, the direction of dip being about 30° S.W. The result of plotting the Section reveals the fact that the Irwell Valley Fault on the section line indicated has a throw down to the north of 945 yards as measured on the angle of the fault, or if measured vertically gives a throw down of 1,030 yards, the respective measurements being shown on Section, along with the approximate depths to the various mines.

For the purpose of explaining, so far as my information is available, I have decided to take the route of the East Lancashire Railway from a point thereon north-east of Kilcoby onwards to Bury. The first disturbance of the mines after leaving that point is a fault having a throw up to the north of about 40 yards, which crosses the railway at a distance of about 150 yards south of steps that connect the Higher and Lower Heaps Farms situate in Outwood; this fault, running in a direction of about 35° N.W., cuts under Cream's Paper Works in Little Lever and increases in size, running in a westerly direction, and will be about 65 yards under the aforementioned paper works; leaving this fault, which is known

as the Nob End Fault, and following the line of railway, the coalfield is uninterrupted until we arrive at the stone bridge crossing the railway, near Outwood Ironworks, where a fault having a downthrow to the north of about 500 yards occurs, and running in a south-easterly direction the line would pass through the old Cotton Mill at corner of Park Lane, in Whitefield. The aforementioned downthrow brings in the Worsley Four Feet Mine, which at this point is found at its most northern limit; it was worked at the Old Whitefield Colliery a little to the north of the level crossing under the railway, and was about 15 yards deep under the metals. Continuing along the railway, the next fault is proved running under a brick arch bridge a little to the south of the viaduct which crosses the River Irwell; this fault has a throw up to the north of about 150 yards, and joins the 500 yards fault on the east of the railway. From the 150 yards fault and continuing along the railway, no serious dislocation occurs until we arrive at the bridge which carries Blackburn Street over the railway; here a fault occurs with a throw up to the north, the size of which has not been proved with certainty; it is between the aforementioned faults that the Stand Lane Coal Company on the east of railway, and Messrs. Andrew Knowles & Sons on the west of railway worked the Three Yards and Two Yards Mines, and latterly in the same belt of coal, Messrs. Knowles worked the Doe, Five Quarters, Trencherbone, and Cannel Mines, which mines they ceased to work about 1886. Passing onwards along the line of railway from this fault we get about 100 yards of barren or broken ground until we arrive at a down fault to the north of about 20 yards, which crosses the railway about 100 yards from Blackburn Street Bridge; this fault brings in the coalfield worked by Messrs. Andrew Knowles & Sons, Limited, at Whittaker Bridge Colliery, the mines worked being the Three Yards and Two Yards

Mines; the depth at Whittaker Bridge Pit being 71 yards to the Three Yards Mine, and 102 yards to the Two Yards Mine; this coalfield extends under the railway for a distance of about 500 yards, when it comes in contact with a fault throwing up to the north about 220 yards, and crossing the railway about 200 yards north of Radcliffe Goods Station. There are no mines worked in this coalfield below the Two Yards Mine. The aforementioned faults run parallel with the Radcliffe and Bolton line, and the seams have been worked to the River Irwell on the dip side, and on the rise side to the outcrop for a distance of 1,200 yards to the N.W. of the East Lancashire Railway; this is the most northerly part in which the Three and Two Yards Mines exist in this district. Leaving the 220 yards up-fault and following the East Lancashire Railway in the direction of Bury for a distance of 800 yards, which brings us 180 yards north of Withins Lane Bridge; we here find an up-fault to the north, with a lift of 90 yards. It is between the 220 yards up-fault and the 90 yards up-fault that Messrs. Andrew Knowles & Sons, Limited, sunk Withins Lane Pit, of which the following Section shows the mines passed through in sinking:—

SECTION OF MINES SUNK THROUGH AT WITHINS LANE PIT, IN THE TOWNSHIP OF RADCLIFFE.

Name of Mine.	Thickness of Mine. Ft.	in.			Depth from Surface. Yds.	ft.
Coal	2	0			40	1
White Mine	1	6			48	2
Black Mine	1	6	Coal			
	0	3	Dirt		60	2
	1	6	Coal			
Coal	2	4			67	2
Coal	2	2			101	0
Gingham Mine	1	8	Coal			
	0	3	Dirt		108	0
	0	8	Coal			
Coal	3	0			144	2
Doe Top Coal	3	0			172	1

Name of Mine.	Thickness of Mine. Ft.	in.			Depth from Surface. Yds.	ft.
Doe Middle Coal	1	6		....	173	0
Doe Bottom Coal..	2	6		....	174	1
Five Quarters Mine..	1	0	Coal			
	0	6	Dirt	.. ..	178	0
	2	9	Coal			
Coal..	2	0		....	210	0
Supposed Trencherbone Mine..	1	8		....	265	0
Cannel Mine..	2	3	Coal			
	0	6	Dirt	.. ..	324	0
	2	3	Coal			
Queen Coal	1	8		....	333	1
			Bottom of Shaft	..	334	2

Note.—All depths are given to bottom of Coal.

The mines worked by Messrs. Knowles in this coalfield were the Doe, Five Quarters, and Cannel Mines, the dip of the mines being 1 in 4½, and the direction of dip 70° S.E.

Passing the 90 yards up-fault along the railway, we come to the old Hag Side Colliery, which was sunk to the Cannel Mine at a depth of 277 yards, and following the railway in the direction of Bury the mine rises on the same line as the railway at an inclination of 1 in 5 until we arrive at Openshaw Fold Pit, which was 130 yards deep to the Cannel Mine. Continuing along the railway in the direction of Bury for a distance of 500 yards from Openshaw Fold Pit a fault occurs having an upthrow to the north which throws out the Cannel Mine, and this probably is the most northerly point on the East Lancashire Railway where the Cannel Mine is to be found, being about 1,300 yards on the Radcliffe side of Bury Station, up to which point from the 90 yards fault between Withins and Hag Side Collieries the Cannel Mine is all worked out. The Cannel Mine has been worked within 200 yards or so of Bury Bridge, north side of and close to Irwell at its outcrop.

Some years ago an interesting boring was put down from the bottom of No. 1 Engine Pit, Bank Top Colliery, situate at Bank Top, between the Manchester, Bolton, and Bury

Canal Reservoir, and the Manchester, Bolton, and Bury Canal, of which the following Section is a record :—

SECTION OF MINES SUNK THROUGH AND BORED AT THE No. 1 ENGINE PIT, BANK TOP, BY MESSRS. KNOWLES AND OTHERS, IN THE TOWNSHIP OF RADCLIFFE.

Name of Mine.	Thickness of Mine. Ft.	in.	Depth from Surface. Yds.	ft.	in.	
Coal	0	5	44	2	5	Sinking.
Binn	0	2	44	2	7	
Coal	0	5	45	0	0	
Binn	0	4	45	0	4	
Coal	0	10	45	1	2	
Warrant	8	7	48	0	9	
Coal	1	3	48	2	0	
Binn	0	4	48	2	4	
Coal	0	7	48	2	11	
Coal	2	3	94	2	10	
Coal	0	3	129	1	6	
Warrant	3	0	130	1	6	
Coal	0	7	130	2	1	
Coal (Cannel Mine)	3	8	159	0	10	
Binn (Cannel Mine)	0	6	159	1	4	
Coal (Cannel Mine)	2	6	160	0	10	
Queen Coal	2	3	162	1	4	Boring.
Coal (Supposed Plodder Mine)	1	2	195	1	7	
Dirt (Supposed Plodder Mine)	1	9	196	0	4	
Coal (Supposed Plodder Mine)	0	8	196	1	0	
Dirt (Supposed Plodder Mine)	2	5	197	0	5	
Coal (Supposed Plodder Mine)	0	11	197	1	4	
Dirt (Supposed Plodder Mine)	0	4	197	1	8	
Coal (Supposed Plodder Mine)	1	1	197	2	9	
Coal	1	4	207	2	11	
Coal, supposed Yard Mine	1	3	234	0	8	
Coal	1	5	273	0	4	
Coal (Supposed Arley Mine)	1	10	352	1	2	
Binn and Dirt (Supposed Arley Mine)	0	2	352	1	4	
Coal (Supposed Arley Mine)	0	4	352	1	6	
			No Coal.			
Total depth from top of Pit to bottom of Borehole			497	1	1	

NOTE.—All depths are given to bottom of Coal.

In conclusion, you will perceive I have traced the mines from the Irwell Valley Fault in the hamlet of Outwood, and given the depths to the various mines on each side of the fault, onwards along the East Lancashire Railway to a point about 1,300 yards south of Bury Station, covering a distance of about two miles, and have described the various faults that cross the railway which form the various coalfields, and have also given a Section of the sinkings at Withins Lane Colliery, which I consider is the last to be found, showing the central group of mines in the Middle Coal Measures, till at last, before reaching Bury, they are faulted up, and disappear. I have also given a Section of the sinkings and borings at Bank Top Colliery, which is useful, in so far as it shows no workable seams to exist under the Cannel Mine in that district; indeed it is typical of all the provings that have been made in the coalfields north of the Irwell Valley Fault below the Cannel Mine; and although in the Wigan coalfield, the Yard, Bone, Smith, and Arley Mines underlying the Cannel are found to be excellent seams and extensively worked, I think in this district we may safely fix the Cannel Mine as being the lowest workable seam, for all attempts that have been made to prove the seams under the Cannel Mine as workable in this district have proved utter failures.

The PRESIDENT: You have all had the pleasure of listening to Mr. Pickstone's interesting paper. There are several points of great interest in it, but I shall first call on Mr. Dickinson to propose a vote of thanks to Mr. Pickstone.

Mr. DICKINSON: I have pleasure in responding to your call, and I move that the thanks of the meeting be given to Mr. Pickstone for his paper. As regards a large portion of the paper it will, I think, be found exceedingly useful to

those who are interested in coal working, notably in the localities mentioned, the section of the beds in the neighbourhood of Withins Lane Bridge and those at Bury. According to the late Mr. John Hall's view, the mine Mr. Pickstone has alluded to, under the town of Bury, was identical with the Arley, of Wigan, and the Royley mine of Oldham. It does not, however, resemble either of them in quality. Perhaps Mr. Pickstone who spent much money in exploring the Bury part of the field, will kindly tell us what he thinks it to be. He bored for coal in several places, and gave me a copy of the sections. They are rather abstruse. So much so, that when Professor Edward Hull was marking down the geology of the Lancashire coalfield, and came to this part, he asked the question whether it was possible this part of the coalfield was unconformable with the main field. Anyhow Mr. Pickstone can, if he feels disposed, tell us the result of those borings he made many years ago.

Mr. GERRARD: I beg to second the proposition. Mr. Pickstone has touched upon one of the points which to me was the attraction of this meeting. I thought that I should get some information as to the Arley mine in this part of the coalfield. I should be very glad if Mr. Pickstone, after his attention has been drawn to this point, can now or subsequently give us any information regarding actual facts, sections, and so on, that would throw light on the question of the continuity of the Arley seam in that part of the district.

Mr. PICKSTONE: The coal that has been got there was similar to the Arley. They have a better kind of coal than that found at the south-east of that place. I think that section is altogether different from that removed from it by half a mile or two miles. The seam of coal that I found at

Bury, and proved for a distance of 100 yards under the town of Bury, and west of it, or south-west of it, was a four-feet seam of indifferent quality. When I punctured it, I came to the conclusion it was a very good seam indeed, and I told Mr. Statter so; but it proved to be of a poor quality, more like that worked to the north many years before by Messrs. Walker and Lomax. I do not think myself there is any coal between the seam I punctured and the Mountain Mine in that district, and therefore, you will see there was a great depth of shale between the one I punctured and the other seams. They cannot be worked by anyone for profit except Lord Derby himself. A seam of coal was cut near Hollins that was similar coal. And so far as I know the Heywood and Middleton coal is all of that poor quality representing what I call the exhaustion of the field as it approaches the millstone grit.

Mr. DICKINSON: The Hinds mine worked at the old Elton colliery was the cannel of Wigan, but that under the town of Bury, called the Dogshaw, is nearly eight feet thick, including dirt beds, and is of poor quality. The Hinds mine was good. When the Middleton Tonge colliery was at work they had other seams and some of them were considered good but they had too much water.

Mr. GERRARD: At Heywood and Royton there is a good Arley seam.

Mr. DICKINSON: The Arley mine as it comes from Wigan to Bolton deteriorates in quality. It is very thin at Farnworth and there is none or scarcely any left on the north side of the great Irwell Valley fault.

Mr. PICKSTONE: I don't know whether any one here knows anything of the finding of a seam of cannel more

or less intact at Darcy Lever. It was thought to be a grand find and that it was going to make the shareholders rich.

Mr. GERRARD: It has proved an uncommonly good seam, and correlates with the Wigan cannel. In the neighbourhood of Wigan there are five faults, almost parallel, three having a throw of 600 yards. The seams of coal on each side of these large faults do not materially differ in quality. The faults mark no change in the nature of the seams. It does not follow that by reason of a fault a good seam of coal is changed into a bad one.

Mr. PICKSTONE: That is proved in this case. The seams to the east of the great fault have not the quality of those to the west.

Mr. GERRARD: I hope some day there will be further trials made.

The PRESIDENT: As to the materials that have gone to form the coal I thought Mr. Pickstone made a startling announcement. If I understood him right his view is that the bulk of the material came from the fruit of the trees. It is difficult to believe that fruit alone has produced such an amount of matter as that which goes to form a seam of coal. The trees that grew in the early ages of the coal fields were filled with masses not only of cellular tissue but vascular. You are bound to have in large plants like that a series of vessels that will convey from the roots the raw material, so to speak, up to the leaves, and another set of vessels that will convey the sap to do its work. What became of the material that filled those trunks? It seems to me to be going rather too far to say that fruit is the basis of coal formation.

Mr. PICKSTONE: To my mind we have no evidence of the woody nature of the trees to which the bark you speak of belongs.

The PRESIDENT: Most certainly we have. You must have seen sections. The trunk of the tree must have contained woody tissue.

Mr. PICKSTONE: I was thinking of the aloe which throws up a stem in a single season to a great height, and there are no leaves from the bottom to the top, but on the top the tree produces a marvellous quantity of fruit—cakes you might call them. In like manner the bamboo throws up a stem rapidly to a great height without a single leaf. I have seen the aloe between 20 and 30 feet high. They are wonderful looking things. I brought from South Africa a part of a stem and part of the fruit which I gave to Mr. Leo Grindon who put it among his specimens of trees and plants so carefully that he could not find it for me. Now I say anyone who will examine the dividing lines of the coal, will find something that is not coal, and will find among other things, timber reduced to charcoal.

THE ACCUMULATION OF SOLID MATTER IN STEAM BOILERS AND HOW TO MINIMISE THE TROUBLES CAUSED THEREBY.

See Part IV., Vol. XXVII., Manchester Geological Transactions.

Mr. T. ASPINALL, F.C.S., recapitulated the points of his paper, on how to minimise the effects of scale in steam boilers.

Mr. DICKINSON: When this paper was read last February, I brought before the Society some remarks of the late Mr. Peter Spence, who, at one of our meetings, some years ago, told us how he was able to use very dirty water in his boilers, by always keeping it alkaline. Mr. Aspinall, in replying to that, said that what the late Mr. Spence said about the water was perfectly true, but it would be perfectly false to apply the same reasoning to another water in another district. I see that in July last, a paper relating to the same subject, was read before the North Staffordshire Institute of Mining and Mechanical Engineers by Mr. J. Kent Smith. He has given a title to his paper which is rather misleading—"water softening" is the title—which many might not connect with water for boilers. He treats the subject very much as Mr. Aspinall did, mainly from the chemical point of view, and partly from a general point of view. He holds it of great importance that all possible impure matter should be removed by filtration or in some other way before the water enters the boiler. By so doing you materially aid in getting rid of the scale by the sludge valve. He also says that in softening the water you must be very careful not to put too much of the neutralising matter in, or you will do more harm than good. And he states, that any acid in the water has a wonderfully quick effect in seizing upon iron and corroding it.

Mr. ASPINALL: Yes, it forms a salt.

Mr. DICKINSON: He refers particularly to such water as we get here or in the neighbourhood of large towns. A discussion took place upon the paper. Evidently there were some practical men present, some inclined to the view that potatoes had a useful effect in correcting the acid qualities in water, and also to the use of mineral oil. Allusion was made to the fact that many of the boiler inspectors set themselves against the use of oil in any shape, but the speakers adhered to their view that pure mineral oil had a wonderful effect in cleaning the boiler; but you must cease using the oil as soon as you get the boiler clean.

The PRESIDENT: This water question is one of very great interest to me, not only chemically, but financially. I have found it an advantage to use waste steam for softening purposes, and caustic soda in order to get rid of lime in the water.

Mr. CHARLES PILKINGTON: Do you take any means to keep the oil out?

The PRESIDENT: The oil is not a good thing for boilers. It has a peculiar effect on the iron.

Mr. PILKINGTON: The reason I mentioned oil was this. Formerly tallow was used for greasing the condensing engines, and it was considered very bad indeed for the boilers, into which it entered with the feed water. It caused grooving on the piston rods. Then mineral oil came into vogue. It was cheaper, and did less harm, but I think it is very necessary to keep all oil out of boilers.

Mr. DICKINSON: I have heard of an explosion taking place when men have gone with an open light into a steam boiler to clean it. If mineral oil were put in the danger might be increased.

The PRESIDENT: It does not stop in very long; it passes with the steam. If it does not go in that way, when

you get too much in, there is a chance of priming and it all rushes away.

A MEMBER: Of the use of materials in boilers I have had a good deal of experience. In dealing with scale in boilers, the only means of removing it, I found, was to put vegetable matter in, and blow off the water frequently. I blow the water off once a week and find it a very effective method for getting rid of the effects of scale. Catechu and cow's dung have been found very effective in preventing the precipitation of lime, and the consequent formation of scale.

Mr. ASPINALL, in replying to the discussion, said: Mr. Dickinson referred to Mr. Peter Spence's method of keeping the water in the boilers alkaline. This keeps them free from corrosion, but it will not keep a boiler clean if there are lime salts present in any quantity. The President mentioned the softening of water by utilising waste steam and using caustic soda. It is a very good thing to utilise all waste steam if possible, as it heats the first water, and thus economises the fuel; then it also throws down the carbonate of lime before going through the economisers, so preventing the lime from being deposited therein. Another method of water softening was mentioned, viz.:—Adding lime in just sufficient quantities to combine with the carbonic acid that holds the carbonate of lime in solution. This is a very delicate method, and requires a skilled man to put it into practice. If insufficient is added, the work is not properly done, but if an excess is added, the last state of the water is worse than the first. The President seemed to think that the system of blowing off three or four inches daily was a costly one, but I feel that if he thinks the matter over, he will find it cheaper than raising and maintaining the solid matter at the requisite temperature, besides coating his heating surfaces with a bad conductor of heat. Mineral oil was mentioned, and when it had been used, corrosion was

found on the plates at the water level. There is nothing in the mineral oil itself to cause corrosion, but in keeping the plates clean at the surface of the waters it allows the purest form of water—the steam just in the act of being converted—to act on that part of the plate, and dissolve a portion of it, owing to its great solvent power at that time. Mr. Pilkington mentioned the use of tallow and the corrosion caused in the cylinders and pistons. The cause of this is due to the glycerine being expelled from the tallow, and a residue of free fatty acid being left. This acid is corrosive, especially at high temperatures. Mention was made of the use of catechu; also cow's dung. Catechu is a compound containing a large percentage of tannic acid. This forms tannate of lime when it comes in contact with lime in the form of carbonate, and forms a fine powder that does not adhere to the plates. The action of cow's dung is simply mechanical. A member said the best system he had found for keeping his boilers clean was to blow off the boilers once a week. In this case he blows off the solids whilst they are practically all in solution. Therefore there is no suspended matter to adhere. I herewith give you an instance showing this. A series of boilers consuming $7\frac{1}{2}$ tons of coal per day per boiler, and using a water containing $52\frac{1}{2}$ grains of solid matter, fed into each boiler 11·76 lbs. per ton of coal, 88·2 lbs. per day, 539·2 lbs. per week, 24·75 lbs. on filling each boiler. So that at the end of one week there were 563·9 lbs. in each boiler. You will now see the advantage of the method of blowing off with only 564 lbs. of solid matter in each boiler, instead of letting the solids accumulate to 2,185 lbs. as they would have done in this case in three weeks' time.

On the motion of Mr. GERRARD, seconded by Mr. PILKINGTON, the thanks of the meeting were tendered to Mr. Aspinall.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XXVII. SESSION 1901-1902.

An EXTRA MEETING of the Members was held, at the invitation of the Council, in the Geological Museum and the Beyer Buildings, Owens College, on the evening of Friday, 10th January, 1902, when Mr. JAMES STIRLING, Mining Representative of Victoria, delivered a lecture on "The Coalfields of the Colony of Victoria."

Professor BOYD DAWKINS, F.G.S., occupied the chair.

THE COALFIELDS OF THE COLONY OF VICTORIA.

By Mr. JAMES STIRLING.

Mr. Stirling, in the course of his lecture, which was profusely illustrated by lantern slides, said that coal was first discovered at Cape Paterson, on the South Coast of Victoria, in 1825, by the explorers Hovell and Hume. It was found outcropping in the strand at low water. In the early fifties Dr. Selwyn, first Government Geologist of Victoria, reported on the discovery, and expressed the opinion that larger and more persistent seams would be found inland in the dense forest regions of South Gippsland. Fossils discovered in the rocks of the locality were submitted

to the late Professor McCoy, who pronounced them to be of the same age as the Oolitic beds in Great Britain, or the Jurassic of the continent.

Further investigations were made by a Parliamentary Committee, and a rough survey of two of the coal bearing areas was carried out by the lecturer's predecessor, Mr. Reginald Murray, with promising results; Mr. Murray having predicted the more recent developments.

About ten years ago the lecturer was deputed to investigate the Gippsland coalfields, determine their character and extent, and select sites for boring operations.

At that time the colony was importing her coal supplies from the neighbouring colony of New South Wales at an outlay of £750,000, a year.

He was able to prove that at several localities within an area of 3,000 square miles of coal-bearing rocks, there were several seams of good black coal, ranging from two feet to five feet in thickness, namely at Korumburra, Jumbunna, Outtrim, Cape Paterson, Kilcunda, Berry's Creek, Bass Valley, and Hazelwood—no less a quantity than 56 million tons being available for local production.

The absence of railway communication and the dense forests made transit almost impossible, and the conflicting interests of coal importers retarded development for a few years. Now, since railways had been extended into the area, there were quite half-a-dozen collieries at work, employing nearly 1,000 miners, and giving an annual output of 250,000 tons of coal. The total output to date was 1,750,000 tons, of the value of one million sterling.

There were three well-defined coal-bearing areas in Victoria, the Gippsland district already mentioned, that at Cape Otway, and that at Wannon—the whole covering an area of 7,000 square miles.

There were two distinct classes of coal—the Jurassic black coal, and the Tertiary brown coal—the latter being found in deposits of enormous thickness. The lecturer threw upon the screen photographs of the dense forest growths which the geologist had to cut through when investigating fault lines in the strata, to determine the site for boring operations. Another view represented fossil plants, brought from a depth of 1,000 feet, of the genera podozamites, taeniopteris, and sphenopteris. These and other fossil plant remains indicated that ferns grew in the humid valley of the period; palm-like plants in islands, in lakes, and coniferous plants in the high ridges surrounding the lacustrine areas, which were all intermingled to form the coal seams. They were all drifted into the waters of lake basins, and were not formed by the growth of forests *in situ*, as appeared to be the case with British coal beds.

In the Victorian Jurassic beds, with their rapidly alternating deposits of false bedded sandstones and shales, and also beds of agglomerate, there were everywhere evidences of transportation by fluviatile and lacustrine agencies. There was no under clay, and there were no beds to represent the soil on which the plants grew.

Mr. Stirling proceeded to compare, with the aid of many illustrations, the Gippsland coal plants and those of the Jabulpur and Kach beds in India, which, he said, disclosed a remarkable identity of generic forms in the fossil flora of these two widely separated areas. A comparison with South African forms, where the beds were believed to be of Triassic age, revealed further resemblances. A similar comparison with portions of the fossil flora of Mesozoic formation in Queensland and Tasmania yielded data for purposes of correlation, and indicated a vast southern and Ant-arctic continent to which the name of Lemuria had been given.

With regard to the quality of the Victorian coal, the lecturer said it was a good steaming and domestic fuel, giving off comparatively little smoke, and it could therefore be used with advantage for naval purposes. The average of a large number of proximate analyses gave the following result :—

	Per Cent.
Water	4·20
Volatile Hydrocarbon	28·36
Fixed Carbon	58·64
Ash	8·8
Calorific Value	1·183 to 1·330

The coal was in use on all the Victorian railways and at the principal mining centres.

At Cape Paterson, where coal was first discovered, there was a seam with an average thickness of 2 ft. 6 in. to 3 ft, and from borings he estimated that this coalfield contained 6,748,000 tons of available fuel.

At Kilcunda, 12 miles away, the seam was 2 ft. 6 in. thick.

At Korumburra coal creek there were three distinct seams, one of 3 ft. at 80 ft. from the surface, one of 2 ft. 6 in. at 486 ft. from the surface, and one of 3 ft. 5 in. at 539 ft. from the surface. These were now being worked. He estimated the quantity of coal available by boring at Korumburra at 26,814,000 tons.

At Jumbunna, six miles south of Korumburra, the seams averaged 4 ft. in thickness, and in places reached 5 ft.

Immediately the coal seams were opened, contracts were entered into with the Victorian Government, with the result that the price was reduced from 20s. or 25s. a ton to 10s. Although the black coal beds of Victoria did not attain to the thickness of the seams in New South Wales and Queensland, yet they were of great commercial value, and with the clearing of forest areas and the extension of railway communication the colony would become self-contained so

far as its supplies of black coal were concerned, and might even have a quantity available for export in time of need. There could not be a lesser quantity available in the Gippsland beds alone than 200,000,000 tons.

Passing on to the beds of Tertiary coal, Mr. Stirling said that beds of the Eocene, Miocene, and Pliocene age occurred directly overlying or flanking the areas occupied by the coal formation.

In some localities where these Tertiary beds occurred there were evidences of extensive faulting succeeding the invasion of eruptive basaltic rock. This extensive faulting in the Latrobe valley produced enormous depressions at the close of the Miocene period, and into these depressions enormous accumulations of vegetable matter were deposited during the Pliocene age. These magnificent deposits, which were truly phenomenal in thickness in the Latrobe valley, had already been proved to possess certain commercial values, although they had remained undeveloped. The enormous production and utilisation, however, of the brown coal beds in various European countries, especially in Germany, was a sufficient guarantee, in his opinion, that the Victorian brown coal, which was admittedly superior, could be ultimately turned to commercial value.

The average of 120 samples of German brown coal as compared with the Victorian, gave the following results :—

	Carbon.	Hydrogen.	Ash.
German	60·5	5·08	9·05
Victorian	66·92	4·8	3·37

These figures showed that the Victorian brown coals were superior in the value of their constituents, besides containing less ash than the European Tertiary coal.

In the watershed area of the Latrobe valley, in proximity to the main Gippsland railway from Melbourne to Barnsdale, a great thickness of brown coal had been discovered on the

northern banks of the Latrobe, whilst the Morwell Company were now working an outcrop by simply quarrying it from an open face directly into railway trucks.

As an instance of the thickness of the Gippsland deposits, Mr. Stirling mentioned that a bore was put down about 60 chains east of Morwell town, on the Maryvale lease area, and was found to pass through no fewer than seven beds of brown coal.

Three of these proved to be of phenomenal thickness and without parallel elsewhere. The analyses made of samples of the cores showed distinctly the increase of fixed carbon with the depth of the bore, although some of the bands which were apparently more earthy, showed a higher percentage of ash, and consequently a lower percentage of fixed carbon. The greatest percentage of fixed carbon occurred in a sample from a depth of 975 ft., namely 48 per cent. The high percentages of ash in the samples from depths of 718 ft. and 954 ft., which were 15·25 and 22·45 respectively, might be due, he said, to a considerable amount of calcareous sediment present during the deposition of the vegetable material. A shaft was also sunk in the locality to a depth of 300 ft. ; coal was struck 132 ft. from the surface, and continued to the bottom of the shaft. At 1,200 ft. level a drive was put in to the north for 200 ft., and then a cross-cut 175 ft. from a point 50 ft. along the drive. The aggregate thickness of the beds of workable brown coal at Morwell as shown by this bore was actually 781 ft. 5 in.

Speaking of the use to which brown coal could be put, Mr. Stirling said that in the form of briquettes, brown coal had the advantage over black coal in cleanliness, smaller quantity of ash, no clinkers, no broken coal, and cheaper carriage. In addition to its use as a fuel, brown coal was

rich in oils, and in Saxony, Bohemia, and other places in Europe, a large industry was carried on in distilling tar from the coal. From the tar all the different varieties of mineral oil were distilled for lighting and lubrication.

Paraffin was also obtained and made into candles, and the wax used in many other industries was also produced. Brown coal could also be used in the manufacture of bricks made from a mixture of the overclays on the brown coal deposits, and the refuse brown coal. These bricks were, according to Professor Kurnet of Melbourne University, only about half the weight of ordinary brick, absorbed less water, were thoroughly fire-proof, had a greater crushing strain than ordinary bricks, and nails could be driven into them in any direction without causing splitting.

In Austria and Saxony brown coal briquettes were almost exclusively used for locomotives. The speaker said that he had estimated that over a distance of 50 miles in the Latrobe valley there could not be less than 31,144,319,000 tons of this fuel. How to utilise these magnificent Tertiary deposits was, he said, the problem of the hour in Victoria.

On the Continent, in Germany, Austria, and Italy, they had shown us how to put smaller deposits to commercial uses. In Germany, as far back as 1891, the output had reached six million tons a year. With such facts before them, there was every reason to hope that with energy and a little capital, the magnificent deposits of phenomenal thickness which occurred in the colony of Victoria, might be turned to commercial uses. He felt certain that in them they had the germs of a great national industry which only awaited development.

Mr. Stirling, in answer to a question, also described the "long wall" system of working, which he contrasted with the "bord and pillar" system. For the former he claimed

that for small or moderate sized seams of coal, it had the following advantages:—(1) All the coal was won, none being left to support the roof; (2) There was a saving in headings, as they were dispensed with; (3) haulage was simplified, thus securing efficiency at a minimum cost; (4) less timber was required, and (5) the air could be readily taken along the face of the workings. On the whole, he said, the long wall system reduced the cost of putting, supervision, and materials such as rails, sleepers, and brattice.

Where subsidence took place it did so uniformly; accidents were less likely to happen; and no coal was left below ground.

Mr. JOSEPH DICKINSON, in moving a vote of thanks to Mr. Stirling, said that at a time when a Royal Commission is seriously considering whether we have sufficient coal for our wants, in addition to what we export, it is satisfactory to learn that whatever the state of the home mines, there seem to be ample reserves in our colonies.

The vote was seconded by Mr. J. BARNES, President of the Society. He observed that he had a lively recollection of the last visit which Mr. Stirling paid to them. The pictures they had seen revealed a very luxuriant region, and what they had heard of the coal producing properties of the district suggested that they had here the nucleus of a great commercial industry. He hoped it would be developed by British brains.

Professor DAWKINS said there could only be one issue to such a vote, and invited the meeting to carry it in the usual way, and this was done.

Mr. STIRLING, in reply, said this would probably be his last visit, as he was shortly returning to his own native heath in Victoria.

The meeting then closed.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, January 14th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

The President, Mr. JONATHAN BARNES, F.G.S., in the Chair.

Discussion was invited on the Paper read by Mr. JOSEPH DICKINSON, F.G.S., at the Meeting on April 9th, 1901, on

THE PREVENTION OF ACCIDENTS BY FALLS OF ROOF AND SIDES IN COAL MINES.

Mr. DICKINSON said: My review on the prevention of accidents by falls of roof and sides as practised in the Courrières Colliery being an *impromptu*, I was invited by the meeting to read it again. To this I pointed out that if the paper were thought worthy it would appear in the

Transactions, and that having been ably discussed by experienced miners, Messrs. Barrett, Tonge (senr.), Gerrard, and Ridyard taking part, re-reading appeared superfluous. It has been printed in the Transactions, and the Council now announce it for further discussion.

Under the circumstances, the re-opening scarcely devolves upon me. It may however be convenient to some members if I mention the principal points, viz. :—

A process of securing the roof and sides in advance, by extending supports over the lintel and at the back of the side props, leaving most of the props undrawn, and not allowing any to be drawn except by special persons, using special tools, namely a sledge with hammer and point, a cutting chisel, and a rake, each with a handle 8 ft. in length. Also, that in seams with several layers and dipping at more than 10°, the holing must begin at the rise side and extend to the dip; and in thick seams dipping steeply the coal to be worked off from the rise to the dip. The results of such working showed gradual improvement; the deaths by accidents from such falls having been during 30 years ending 1899, an annual average of only 0·29 per 1000 persons employed below ground, and 0·87 per million tons of coal raised; the yearly averages for the latter five years of the term being only 0·126 and 0·348 respectively. Whilst during the corresponding five years in the United Kingdom of Great Britain and Ireland the yearly averages were 0·776 per 1000 persons employed, and 2·048 per million tons; being very near six times those at Courrières.

The cost of pit wood per ton of coal got at Courrières was shown to reach a maximum of one shilling, the average being 8½d., which is very high.

In the discussion the importance of doing everything possible for the prevention of such accidents was expressed, and allusion made to a liability of error in comparing one colliery with thin seams to that of a whole community of collieries, the circumstances of many of which were different; and also to the fact that some of the home thin seam collieries had fewer such accidents than those at Courrières.

The process, although not new for driving in soft ground, was yet worth consideration for uniform practice to guard against the latent dangers from which many miners suffer.

Mr. OLLERENSHAW: I should like to ask Mr. Dickinson for his opinion on the system of working the coal to the dip and as to the effect upon the output.

Mr. DICKINSON: It is generally considered by miners that working down hill is attended with more danger than working on the level course or on the rise. But what I have done is to recite the fact; to state what is compulsory at the Courrières Collieries.

The PRESIDENT (to Mr. Ollerenshaw): You put the question from a financial point of view?

Mr. OLLERENSHAW: Yes.

Mr. DICKINSON: I did not know that I should be catechised on these minute points, for the miners here—some old practical hands—know perfectly well that working down hill, winding up by a windlass being generally necessitated, entails an extra expense; but when we are discussing the principle of safety we had better leave petty points of cost out of the question.

Mr. OLLERENSHAW: I take it to be the opinion of the managers at the Courrières Collieries that working off the dip is the safest. I think that must be so, for in working off the rise there is a tendency for the coal to fall over. The same tendency does not appear in the other cases. But in our own collieries, in my opinion, the effect would be a considerable increase in the price of coal to the consumer, because it would be obtained at greater cost, owing to the difficulty of hauling the coal up-brow as against jigging it down-brow.

Mr. DICKINSON: In the coalfields of South Wales where the seams are divided into "slips" and "backs," sloping at an angle of 30° from the bedding, it is found to be very much safer working on the backs than working on the faces. There used to be colliers who would not work on the face of the slips on account of the danger of coal falling on them.

Mr. MATTHEWS, H.M.I.M.: I was very much pleased with the paper. There has been a discussion lately between managers and inspectors on this subject, and I think they will come to an agreement so that systematic propping will be the rule of the future. The manager of a mine, who knows the nature of each seam, should specify the maximum distance that props should be put apart for the safety of the workmen. It is found that men sometimes delay propping, thinking the place is safe. The inspectors very often find that accidents occur in places that are not accounted dangerous. Men frequently work on in places that are unprotected without any thought of danger. If this new system is carried into effect it will result in greater safety to life and limb. Another point to which Mr. Dickinson drew attention had reference to the method of

withdrawing the timber. There are one or two machines that have been used for pulling out the props, such as Silvester's gablock and chain, and if employers would insist on these being used instead of the hammer there would be fewer accidents.

Mr. DICKINSON: At the Courrières Collieries they enjoin the use of a hammer with a handle 8 feet long, and we know the gablock and chain when provided is still but very little used.

Mr. MATTHEWS: I think the use of that appliance ought to be made more compulsory than it is.

Mr. MILLINGTON: I may say that both miners' agents, inspectors and owners have now agreed that a rule as to systematic timbering shall be adopted. Another rule has been agreed on—a rule referring to tools to be used when withdrawing timber. That has been settled and will appear in the new rules. Every colliery will have to adopt the tools mentioned, which include Silvester's method with a coupling and chain, and the tools will have to be supplied by the owners. Those rules having been agreed to by the three parties, the Home Office will probably agree to them as well. That will bring us nearer to the method adopted in France. The new rules to which I refer have been approved in the districts of West and East Lancashire and Cheshire.

Mr. OLLERENSHAW pointed out that in this country more coal was got per man than in France. He believed that the English miner got double that which the French miner got.

The PRESIDENT: Wages are lower in French mines than in English ones. The Frenchman cannot work like the

Englishman, because he does not live like him. The English miners are the best in the world, because they are a good deal better fed. The Frenchman will go to work taking for dinner a piece of sour bread, probably an apple, and a bottle of cider. That is what he lives on. He does not get a beef-steak. If you try to hurry a Frenchman he shrugs his shoulders and says, "There is to-morrow that has not been touched." In addition to working longer than the Englishman the Frenchman gets less pay.

Mr. DICKINSON: It should be remembered that the average of the seams is much thinner in the North of France than here.

A MEMBER: In working off the dip I think stronger timber will be required because it has a greater weight to support than the timber has which is used when you work from the rise. With reference to the withdrawal of timber it seems to me it would be a good thing if the law prohibited the withdrawal of timber from wide spaces. I do not believe in taking all the timber away. I think it is in trying to get the odd props out that a number of accidents occur.

Mr. OLLERENSHAW: In some of our best managed collieries, results equal to anything that has been accomplished at the Courrières Collieries are shown. No doubt systematic propping and more care in the withdrawing of timber will tend to safety. In that we are all agreed but it is as to the distances at which the props should be set in the separate seams that we disagree. We have undoubtedly improved matters as to the safety of the workmen during the last few years.

The PRESIDENT: I am sure it has been very interesting to listen to the discussion, and it is very good of Mr. Dickinson

to have allowed the discussion on his paper to be re-opened. Some difference of opinion seems to exist, but Mr. Dickinson does not mind that. In my judgment, the owners gain in the end by anything which promotes safety in working. They avoid a good deal of worry, which must necessarily arise when anybody is killed or injured, and there will be less liability to pay compensation claims. Whatever is done in the way of increasing the safety must be a gain to the colliery owner although apparently at the beginning it may cost money.

On the motion of Mr. MATTHEWS, seconded by Mr. OLLERENSHAW, a vote of thanks was passed to Mr. Dickinson.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, February 11th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. JOSEPH DICKINSON, F.G.S., Presided.

IRISH LACCOLITHIC HILLS.

The President, Mr. JONATHAN BARNES, F.G.S., read the following Paper prepared by Mr. G. H. Kinahan, M.R.I.A., District Surveyor (retired), H.M. Geological Survey:—

SOME IRISH LACCOLITHIC HILLS.

BY G. H. KINAHAN, M.R.I.A.,

District Surveyor (retired), H.M. Geological Survey.

Cisterns of subterranean molten matter formerly were not included amongst the forces to which are due the elevation of hills and ranges. Yet, on consideration, they are no mean agent in the formation of conspicuous features in some areas.

To this subject attention has been of late years directed by the Americans, especially in the reports of Professors G. R. Gilbert and Whitman Cross; but on looking back we find they were not the pioneers, as the Laccolithic idea, to quote Horace Woodward, "was pourtrayed" by Charles Maclaren in his Geology of Fife and "The Lothians, 1839, p. 27." As far as we have been able to collect statistics, the following have also written:—

1877. W. H. Holmes and A. C. Peach. *Bulletin, U.S., Geological and Geographical Survey*, Vol. III., No. 3, pp. 551-564.

1877. G. K. Gilbert. *Geographical and Geological Survey, Rocky Mountain District.*

1881. G. H. Kinahan. *Laccoliths, Geological Magazine*, pp. 134-136.

1882. Same author. *Memoirs, Geological Survey, Ireland*, one inch sheets, 158-159.

1885. Professor Suers. *Das Autility der Erde.*

1886. W. W. Watts. *Comdon Laccolith, Montgomeryshire. Report, British Association and Proceedings Geological Association*, Vol. XIII., p. 341.

1887. Neumayer. *Erdgeschickte*, Vol. I.

1888. Professor E. Reyer. *Theoretiche Geologie.*

1894. Whitman Cross. *Fourteenth Report, U.S. Geological Survey*, Part II., pp. 156-241.

1895. Weed and Pirsson. *Bulletin Geological Society, America*, Vol. VI.; *American Journal of Science*, 3rd Series, Vol. I., pp. 467-479.

1896. Same authors. Ditto, 4th Series, Vol. I., pp. 283-300, and pp. 351 to 362.

1896. J. C. Russell. *Journal of Geology*, Vol. IV., pp. 179-180.

1896. G. K. Gilbert. *Laccoliths in S.E. Colorado, from the Journal of Geology*, Vol. IV., pp. 816-825.

W. A. E. Ussher suggested the Laccolithic origin of the Dartmoor granite, but seems to have subsequently changed his opinion.

1893-94. A. C. Lawson. *The Presidio, Votrero, Hunter's Point, and Las Pulgas Laccoliths, San Francisco Peninsula, U.S. Geological Survey*, 15th annual report, pp. 450-456.

1893 (?). Professor Sollos. *Laccolithic character of the Leinster granite chain, Proceedings Geological Association.*

Very exhaustive reports on the Laccoliths, besides other intrudes and protrudes of N.E. Wexford and S.E. Wicklow, were written to accompany the one inch maps 138 and 139, 148 and 149, 158 and 159. That to accompany sheets 158 and 159 was published, but the map, sheet 158 (Ennischarty), was not. All S.E. Ireland included in the above maps and sheets 169 and 170, 180, 181, was ordered to be revised, and in places re-surveyed. This revision and re-survey was made and approved of by Professor Hull, who ordered the maps to be prepared for the engraver. This was all done, the work costing the country over £8,000; besides, as considerable portions had to be re-surveyed, portions of the maps had to be obliterated, adding to the expense. The maps and explanation of sheets 169, 170, 180, 181, were published while the late Sir A. C. Ramsay was Director-General. What he thought of the work can be seen from his printed preface.

Dr., now Sir A. Geikie, saw the finished maps and vocally approved of them, but afterwards, for some reason, the work was cancelled!! the public having for their £8,000 the sheet 149 engraved but never published; memoir sheets 158 and 159, but without a map of 158, which contains nearly all the area; the unpublished maps prepared for the engraver and their accompanying pattern coloured copies. Subsequently there was another revision prior to writing the

so-called Explanatory memoir of the previously discarded maps by Du Noyers; while still more subsequently there was another revision by three or four members of the staff.

All the early observers who more or less suggested the elevation of hills and mountains to subterraneous intrudes do not appear to be quite clear in their conclusion, as, prior to Professor Gilbert's report on the Henry Mountains, the exact relation of the subterranean cisterns to their enclosures appears not to have been perfectly understood. He gave sound premises on which to work, which were admirably carried on by Professor Cross.

In a letter dated October 4th, 1897, Professor Gilbert gives the following as his definition of a laccolith:—"A rising magma forming a bubble like a cistern. If the rising magma communicated with the surface, once the surface communication was established the whole eruptive body would escape." He further states: "It happened that in the Henry Mountains the strata intruded by the igneous rocks were previously horizontal, and as a result the cisterns are approximately symmetrical. In America the term has been used simply but not exclusively in connection with horizontal strata and symmetrical bodies.

My impression is that convenience will lead to the application of the term laccolith to thick intrusive bodies, whether symmetrical or not.

"Inclusions of rock torn from the conduits are very common in some of our laccoliths." The last sentence was in reply to the question: "In America do fragments of the country rock appear in the laccoliths as is a common feature in those of Wexford and Wicklow?"

This authority points out that many of the intrusions of eruptives now found at the surface in the Henry Mountains were originated much below, filling vacancies in the deep-seated rocks, and not having appeared at the surface until

exposed by denudation or brought up by faults. "The lava, instead of rising through all the beds of the earth's crust, stopped at a lower horizon, insinuating itself between two strata, and opening for itself a chamber by lifting all the superior beds. In this it congealed, forming a massive body of trap."

In his exhaustive report on "The Laccolithic Mountain Groups of Colorado, Utah, and Arizona," Professor Whitman Cross would restrict the term to symmetric cisterns of whinstone. Gilbert, however, as above mentioned, would give it a much more extended signification.

The present recorder has pointed out in the Geological Survey memoir of the unpublished sheet 158, page 15, in connection with the laccoliths of S.E. Leinster, that they were intruded into highly disturbed strata, and apparently into vacancies more or less due to their disturbances.

The Irish rocks in the cisterns are various, usually they are traps, gabbro or its allied euryte; but in places they have associated granite cores or other basic root rocks. In some, however, there are typical felstone cores with their more silicious elvans and granites—as mentioned in the memoir above referred to (Sheet 158). In the igneous filling, or associated with it, there may be fragmentary rock which, as suggested by Gilbert, must have been torn from the conduit and shoved in before the igneous intrusion or incorporated with it.

Therein it has been pointed out that in contorted rocks, on account of their fractured character, such adjuncts ought to be more numerous than if the laccolith was injected into the horizontal strata.

The "baked rock" envelope, due to Paroptesis or Contact metamorphism, may be of varying thickness, due to the ends, not the planes, of bedding being in contact with the

eruptive masses; also on account of the composition of the sedimentary rocks, possibly none being alike; besides, the aqueo-igneous heat given off or generated by the molten mass would penetrate further along some of the lines of bedding or other structure lines than along others. According to their constituents when baked, or rather, stewed, the resulting rocks are very various; also some are more altered in depth, others in quality.

Laccolithic hills occur in various districts in Ireland, but in general, as such, they have been ignored. As far as the writer's experience and observations have gone, those having whinstone cores are most symmetric in outline, similar to American buttes.—A butte in America is nearly sure to indicate a laccolithic hill.—Similarly in Ireland. A most characteristic butte is Doon Hill, Connemara—it having all the character of a laccolith—a dolorite core with an envelope of baked rocks. It has been suggested in a paper published in the Transactions of the Royal Irish Academy, that the mass occupies the throat of a recent volcano. But the supposed proof brought forward tends to prove that the trap is of the same age as the Antrim Eocene or Miocene dolorites.

South-east Leinster seems to be the great Irish area for laccolithic hills, as many of the whinstones, felstones, and certain granites in the Counties Waterford, Wexford, and Wicklow, seem originally to have been deep-seated cisterns of molten matter now more or less exposed by denudation. Those in which the core is whinstone have usually the more symmetrical outlines. The majority of these laccoliths in the Counties Wexford and Wicklow were carefully mapped and described, but the descriptions, as already pointed out, have not been published.

Before proceeding, it should be mentioned that all intrudes that have elevated the superior strata, and con-

solidated while deep-seated, may not be laccoliths. A mass may be intruded as a truncated cone, or as a dome, or in a more irregular shape, but the dynamic forces to which its elevation was due was limited and incapable of forcing it to the surface; if it had, the intrude would have been changed into a volcano probably giving off surface sheets of lava.

For this class of corked-up molten matter various terms have been proposed by the Americans; perhaps of these, the simplest, *Bottleith*, may be the best.

Intrudes of both classes occur in the Counties Wicklow and Wexford, as can be seen in the cliff section, some of them being laccoliths, but others apparently or evidently have not that character, as they are crushed up more or less perpendicular; possibly they may have sent out apophes, but their characteristic is an intrude that solely pushed upward, its base as seen being of greater dimensions than its uppermost parts; still, the intrude, however, was distinctly subterranean.

An interesting intrude, figured and described in the Manual of the Geology of Ireland, p. 184, also in the Geological Survey Memoir to accompany inch map, sheet 169, is at Owenduff, close to the west margin of the sheet. It may be a laccolith, if so, it must have been of a very irregular shape, or has since been disturbed by shifts and other faults. There are, four miles to the E.N.E., at Carrickbyrne, two tracts that seem to be laccoliths, that have not been much disturbed by earth movements. In the memoir description of the unpublished map, sheet 158 (Enniscarthy), the intrudes, laccoliths, and otherwise, are very exhaustively described, to which we may refer; special attention may, however, be directed to the isolated hills of Carrickmastia, two miles N.W. of Adamstown, as the boundaries of the different rock are so well defined.

Greenmount Hill, about a mile N.E. of Enniscarthy, illustrates one in which the limits of the hill and the marginal boundary of the "baked rocks" coincide.

In the district contained in sheet 149 (Gorey), there are some very interesting intrudes, of which the details were not published; one of these is Tara Hill, a typical American butte; it is also a typical laccolith, the entire envelope of "baked rocks" being still in existence, except in a few spots of limited extent, where the whinstone (gabbro) has been exposed by denudation. Attention may also be called to the "Little Rock," Arklow; it has a baked enclosing margin, with a core principally gabbro, but into the latter has been intruded a mass of orthoclasic granite. The limits of the marginal "baked rocks" are well defined.

It seems to be a favourite idea with the majority of geologists to believe that an igneous intrude tails off to a point; and if it appears as a truncated bluff and no rocks are exposed at its base, they unhesitatingly will state the bluff is not the termination, but that the intrude must tail off into a point This is a very general feature in most of the Irish maps, also on the Continent and elsewhere, so that geologists that learn principally from maps, and not in the field, firmly believe that intrudes invariably tail off into points. Sheet 169 shows the true mapping of the exotic rocks with truncated ends. On the adjoining maps of parts of Wicklow, Wexford, and Waterford, will be seen the picturesque 'line and point' mapping of the Geikie selection.

In the published map of Wicklow, Wexford, and Waterford, this principle has gone so far as to be an insanity, so that the maps are perfectly misleading, and have generated in speculators some most interesting theories, such as the magnetic influence on intrudes. The fact, however, is that, in the three counties named, nearly all the intrudes are truncated. Those that are inclined to thin down at their

margin being an exception, while an igneous rock tailing into a fine point is a rarity; only one instance could be found. It may be conceived that thin ramifying apophes may do so, yet if they do it is of a rare occurrence, as in general they end off abruptly at a joint line. Some geologists will go so far as to say a truncated end is a physical impossibility. The American geologists, however, recognise the hills due to truncation and give them a special name.

An interesting series is the laccolithic system that elevated the Leinster granite range of hills. Jukes and others seem to have been puzzled to account for this granite being margined by Ordovicians, not Oldhamians; in fact he stated it was always so. The writer, however, is of the opinion that in at least one locality this is not correct. Jukes stopped off the Carrick Mountain Oldhamians at the Avonmore Valley. Wyley, however, would extend them much further S.W. to the Ow Valley, N.W. of Aughrim. For this suggestion there appears good presumptive evidence, and if it is correct, hereabouts the rocks associated with the granite are metamorphosed Oldhamians. (Geology of Ireland, chap. I., p. 15.)

If we believe in the laccolithic origin of these granite hills, this apparant anomaly immediately disappears. Originally there was a floor due to the cutting off of more or less contorted Oldhamians, on which floor the Ordovicinian were accumulated. Subsequently the tract was invaded by granitic intrudes that came up as spurts through breaks in the Oldhamians, lifted up the overlying horizontal Ordovician, and accumulated in cisterns between the rocks of the two formations, while in later times denudation has removed portions of the superincumbent strata, exposing the granite, but in no place except the valley of the Ow was it sufficiently deep to expose the Oldhamians.

The Leinster granites are generally described in the Manual Geology, Ireland, chap. XII., pp. 197, &c., and very exhaustively in the Economic Geology of Ireland, pp. 15, &c.; it would therefore be superfluous to again describe them. It should, however, be pointed out that the original laccoliths* were subsequently invaded by intrudes of newer granite. The most conspicuous of these being a very recent granite, that of the *Aughrim type*. This elsewhere has been suggested to be of possible Carboniferous age. These are always associated with iron-masked rocks and some of the hills due to the intrudes, are now typical buttes, such as Carrick, near Rathdrum.

A *butte* in America is an abrupt hill with more or less sloping sides, while a hill having perpendicular sides and a flat top in South America is called a *mesa*. A typical Irish mesa is the "Bell Rock," Avoca Mines, an intruded neck of felstone. Another granite intrude that apparently is a laccolith is Slive Crook, County Down. The metamorphism in connection with this intrude is remarkable, because, as first pointed out by Traill, it affects not only the envelope of sedimentary rocks but also the crust of the laccolith, producing in it a foliation not found in the mass of the granite.

Scattered about through Ireland are other laccolithic hills to which attention may be directed, but we will not attempt to enumerate them, as our knowledge of them is not as intimate as would be desirable; we would, however, call attention to some protrudes that might be mistaken for laccoliths—such as Benchoona, south of Lough Muck, Salrock, Co. Galway. This hill at first would seem to suggest a laccolith, but on examination it appears to be evidently a protrude around which the sedimentary rocks were accumulated.

* In the Geology of Ireland these Leinster granites are called protrudes; they are more correctly intrudes.

A most conspicuous protrude is the skeleton of the great Carboniferous volcano of the plains of Limerick. Here the first eruptions took place in early Carboniferous times; a second considerable outburst was in middle times, that is, just at the beginning of the Coal measure age; while a third was much later, coming up through the Coal measures.

The newest rocks may be of Triassic age; or it may be suggested that they are possibly Tertiary, as they are very similar in aspect to known Tertiary rocks elsewhere in Ireland.

Mr. DICKINSON: We are indebted to Mr. Barnes not only for reading this long paper, but also for deciphering it. Due it appears to a touch of rheumatic gout, with which we all sympathise, it was written rather illegibly, so much so that the reading of it was deferred at our last meeting. It must needs be a purely scientific paper relating to a theory of geology on which, in the presence of my old friend Professor Boyd Dawkins, I will bow to any opinion of his. Mr. Kinahan has long been an honorary member of this Society, he is an old representative of the Geological Survey of Ireland, and now in his retirement he still seems disposed to keep some of us rising geologists informed of what is new, and what, no doubt, is of great interest to him. It seems a pity we have not this map before us to which he alludes. Some difference of opinion seems to have arisen with regard to the publication of it. I am not quite sure if I have seen it, but I rather think if it is the one I have in my mind it detailed the basic rocks most minutely, showing all the different changes, not only of structure, but of the constituent minerals. In fact it would remind an ordinary person very much of one of the diagrams one sometimes sees in shop windows, showing the human frame with all the arteries and veins and nerves

ramifying through the system. I am not surprised the map is not here if it was going to cost such a large sum of money. It cost £8,000 as it was, and seeing it was so detailed and of so little interest to the general public, it was not thought worth while for the Government to undertake any further expense. I move a vote of thanks to Mr. Kinahan for his paper. No doubt it will be interesting to some members, but it is a little beyond my knowledge.

Professor BOYD DAWKINS: I beg to second the vote of thanks, but really I am very much in the position, with regard to the communication itself, as our Chairman is. We have not the map. I don't know the country, and unless I had further information than is represented by the diagram, I should not altogether be inclined to take it that it would be absolutely proved by an examination of the ground. It seems to me such a symmetrical elevation as this, in connection with a symmetrical outburst of volcanic material, would take a great deal of room. I feel on the evidence before me very considerable difficulty in really holding any view in regard to this particular district. But nevertheless, with regard to the somewhat smaller elevation of the rock disturbances which have been observed by Dr. Gilbert, there is very good proof, in this measured section, which he gives, of certain districts of Western parts of America. I feel I can add nothing to this discussion except that very small criticism.

The following Paper on "A Metamorphosed Limestone at Peak Forest" was read by the President, Mr. J. BARNES, F.G.S., and illustrated by a series of lime-light views, microscopic sections, and hand specimens.

ON A METAMORPHOSED LIMESTONE AT PEAK FOREST.

By J. Barnes, F.G.S.

For a very long time, and up to within a few years ago, the whole of the igneous rocks found intercalated with the Carboniferous limestone in Derbyshire were believed to be contemporaneous with the limestone: they were believed to

Section in Altered Limestone, Peak Forest.

be so from the fact that much of it (*i.e.*, the igneous rock) shows the well-known vesicular structure, that so well illustrates what happens when a lava outflow takes place upon a sea bottom, viz., the production of the cavities or steam holes as seen in the Toadstone.

In the year 1899, along with the members of the Geologists' Association, and under the guidance of Mr.

Bemrose, I visited a place at Peak Forest, where is to be found an outcrop of igneous rock which is now known to be not contemporaneous, but intrusive. It is interesting to note how the geologist can predict, from a microscopic examination of the igneous rocks, whether it is contemporaneous or intrusive.

Sir A. Geikie, being on a visit to Mr. Bemrose, and after having examined slides of the igneous rock, said it was very probable that the rock from which the sections had been prepared would be found to be intrusive, and that a change in the structure of the limestone would be found. On going to the place at Peak Forest and making an examination, the limestone immediately above the igneous rock was found to be distinctly marmorised; where the igneous rock is in direct contact with the limestone the marmorisation has gone on greatest, whilst receding from this the change that took place is less and less.

The limestone before intrusion is of a fragmental character, and contains remains of encrinites, polyzoa, and forimanifera. (See Fig. I.)

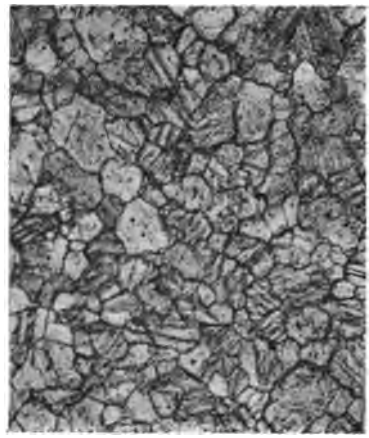


FIG. I.

FIG. II.

The limestone that has undergone the greatest change shows no signs of fossils, all have by the intense heat been completely destroyed, whilst in those beds that are removed from direct contact with the igneous rock they are only partially metamorphosed, and the fossils are visible, but imperfectly. What might be expected, with regard to the size of the calcite crystals in the various phases of the metamorphism, is also well shown, the limestone in immediate contact is very coarsely saccharoid, whilst that removed from the point of contact is much less coarse, this no doubt being due to the fact that the limestone in contact with the intruded and highly heated matter would be raised to a higher temperature, and would as a natural consequence require more time to cool, thus permitting of the growth of larger crystals.

Another way in which the discovery of the existence of an intrusive rock at this particular spot could have been made is by the peculiar appearance of the limestone itself. Walls built of limestone have generally a very uniform appearance, but the walls in the neighbourhood of the intrusion look very different, there being, along with the ordinary and unchanged rock, many blocks that are distinctly white and marbly in appearance. (See Fig. III.) The geologist

Fig. III.

knows that such a rock can only have been produced by the action of heat alone, or by the action of heat in the presence of water, and since the limestone lying immediately above the igneous rock is changed into marble, it may be safely said that the change has been brought about by the intrusion of the igneous rock.

The microscopic structure of the rock before and after the heating shows how great a change has been brought about; the changed rock resembling in structure very much that of statuary marble. (Fig. II.) The carbonaceous matter has in all probability been converted into graphite.

Mr. DICKINSON: We have heard what Mr. Barnes has to say on this subject, and we have seen his beautiful slide illustrations. I move that a vote of thanks be given to him, and after that has been disposed of, there are some further specimens and illustrations of what he has been describing, which members will be pleased to look at.

Professor BOYD DAWKINS: I should like to second this vote of thanks to Mr. Barnes. I really have nothing to add to his very lucid remarks, and I can only say that he has given us another example of very good work which is of very great practical interest, and which is a perfect model of what scientific work should be. We can follow an address like this which Mr. Barnes has favoured us with from beginning to end, and understand it, and I feel personally obliged to him for bringing this matter before us.

The resolution was adopted.

Mr. BARNES then exhibited several microscopical sections and hand specimens of the limestone he had been describing. There were examples of the stone before the action of the igneous material upon it and after. In the first, as he pointed out, the stone was full of microscopic fossils, and in

the other instance the whole of the fossils had been completely destroyed.

Mr. DICKINSON: I should like Mr. Barnes to explain to us, if he will, upon what theory the separations occurred in the limestone, examples of which are before us, have taken place.

Mr. BARNES: I am not going to attempt it.

Mr. DICKINSON: Those of us who have seen the Magnesian limestone, particularly in the county of Durham, will have noticed there are many changes which might be called metamorphic changes, also in the Ardwick limestone close to Manchester, and in some of the Mountain limestone in County Donegal, Ireland. When you look at the immense thickness of some of the beds of limestone, it is surprising how very regularly the joint character continues throughout the whole.

Professor BOYD DAWKINS: The marble is definitely and distinctly a combination of crystals of calcite interlaced and interlocked together, exactly in the same way as the crystals are in the statuary and ordinary marble of Carrara.

Mr. JOHN GERRARD exhibited a Pagoda Stone, and also a specimen of *Loess* collected by Mr. Reid in China, and read the following notes thereon:—

ON THE PAGODA STONE OF THE CHINESE.

By Mr. John Gerrard.

This stone, sent by Mr. Alexander Reid, mining engineer to the Pekin Syndicate, was obtained at I'Chang, on the Upper Yangtze, China, about 1,000 miles from the mouth of the river. The name pagoda stone is a literal translation of the Chinese, and evidently has arisen from the resemblance the chambers bear to the successive stories in a pagoda.

Two similar specimens in the British Museum are described by Dr. Woodward as species of Orthoceras, and labelled Devonian?

The limestone in which this Orthoceras is found extends over a tract of country from 30 to 40 miles by 10 miles, a few miles above I'Chang. The peasants at idle seasons prospect the limestone, when a fine large Orthoceras is found, the stone is cut out in a block, and sawn on the spot into plates or longitudinal sections. They are polished and taken into I'Chang. They are then varnished and mounted in carved frames on stands, and are much admired as handsome and appropriate ornaments wherewith to decorate reception rooms and temples.

For this information I am indebted to a paper by Mr. John Grieve, read before the Natural History Society of Glasgow, April 28th, 1886.

This specimen measures 18½ inches in length, and at the base 2½ inches in width.

The specimen submitted to the Glasgow Society was 24½ inches in length, and 3½ inches in breadth at the base.

Loess. From Geikie.—"In the course of long ages the constant deposit of dust has in these Asiatic countries formed

a massive accumulation which sweeps over the plateau and rises to 6,000 feet or more above the sea, and for wide spaces conceals all older formations" Richthofen describes it in China under the name of Loess, as a wholly unstratified formation of a yellowish calcareous clay, amounting sometimes to 1,500 or possibly over 2,000 feet in thickness.

Professor Boyd Dawkins: The stone is an earthy limestone, probably not older than the Carboniferous. It may however be Silurian.

Mr. Gerrard: The one in the British Museum is labelled "Devonian." (?)

On the motion of Professor Dawkins, seconded by Mr. J. Tonge, a vote of thanks was passed to Mr. Gerrard for his contribution.

Mr. Gerrard also exhibited several fragments of insect wings from the Barnsley seam at Monckton Main Colliery; and said: unfortunately the wings lack the prox. and dist. ends, so that the identification cannot be certain. Mr. H. A. Allen, F.G.S., is led to suppose that they may be fragments of a Borrea, one of the Platypterids.

A vote of thanks to Mr. Gerrard was passed for his exhibition.

A vote of thanks was passed to Mr. Dickinson for presiding.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, March 11th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

The President, Mr. JONATHAN BARNES, F.G.S., in the Chair.

Mr. J. GERRARD exhibited specimens of timber prepared by Aitkins' patent process, which had been in a mine five years, showing apparently no change; also specimens of timber unprepared, from similar places in the same mine for the same period; these latter specimens being almost completely decayed.

Mr. JOSEPH DICKINSON, F.G.S., said that in the Forest of Dean there were now and then found old spades, which it was said were used in the time of the Romans. They were made of oak, and in a state of good preservation still.

The following Paper "On a change in the Mineral Deposit in a Stream that passes through the Yoredale Shales, near Mam Tor," was read by the President, Mr. JONATHAN BARNES, F.G.S. :—

ON A CHANGE IN THE MINERAL DEPOSIT IN A STREAM THAT PASSES THROUGH THE YOREDALE SHALES AT MAM TOR.

By Mr. JONATHAN BARNES, F.G.S.

The black shales that overly the mountain or carboniferous limestone, which are commonly known as the "Yoredale Shales," resemble the shales of other geological formations, inasmuch as they contain a very common constituent, viz., iron pyrites or ferric disulphide $Fe S_2$.

Water, containing dissolved air or oxygen, coming in contact with this mineral sets up oxidation, whereby the sulphur is converted into sulphuric acid and the iron into oxide, the sulphuric acid unites with the iron forming ferric sulphate or persulphate of iron, this solution in its further passage may become basic by taking up more iron from the carbonate, which is also a common body in the shales, and it may be rendered basic by having a portion of the sulphuric acid neutralized by the carbonate of lime that is associated with the shales.

This basic sulphate of iron is a very unstable body, as it decomposes very readily on exposure into hydrated oxide of iron and normal persulphate of iron. The hydrated oxide, $2 Fe_2O_3 3 H_2O$, being deposited as a deep brownish-yellow substance, known as yellow ochre. This mineral is of very common occurrence, being very often noticeable in the deposit from the waters of coal measures and other shales.

For many years I have observed a small stream of water that issues from the black shales at the base of Mam Tor, near Castleton. I have observed it in the following

manner: that when passing by the streamlet I have often partaken of the water on account of its highly ferruginous character.

As recently as the 29th of September last, 1901, I visited this particular flow of water, and found it the same in nature that it had been for years, i.e., possessing its usual chalybeate character, with the customary deposit in the bed of the stream of the highly-coloured ferric hydrate or limonite, $2\,Fe_2O_3\,3\,H_2O$.

On the 19th January of this year, 1902, I was in the same neighbourhood, and was much surprised to find a most complete and astonishing change in the nature of the deposit, instead of the usual ochry layer, I found one of an almost white substance, lying upon and almost obscuring the yellow ochre.

The great change was one that would be likely to arouse one's curiosity, and with a view to finding out, if possible, what had been the cause of the change, I visited the spot again a few weeks later, and brought away with me a sample of the water, and also a specimen of the deposit. An analysis of the water shewed that it contained no less than 53 grains of solids to the gallon, which is a very large amount. The main constituent, on testing, was found to be sulphate of alumina, with some sulphate of lime and a trace of iron.

Now, aluminium, does not, like iron, form with sulphur a sulphide; then how has the sulphate of alumina found in the water been formed?

I take it that the ferric sulphate or persulphate of iron has been formed as usual, the solution has afterwards come in contact with a layer or bed of alumina hydrate or bauxite $Al_2O_32H_2O$, the alumina has replaced the oxide of iron, giving rise to ferric hydrate, whilst the alumina has passed

into solution in combination with the sulphuric acid, thus giving rise to the mineral water as it is found in the stream.

The change may be thus represented :—

$$2\,Fe_2(SO_4)_3 + 2\,Al_2O_3 2\,H_2O - 2\,Al_2(SO_4)_3 =$$

Persulphate of Iron. Bauxite or Alumina hydrate. Alumina Sulphate.

$$2\,(Fe_2O_3)\,3H_2O + H_2O.$$

Yellow ochre.

The above re-action shows how the change may take place. The change of deposit is very markedly shewn by the specimen upon the table; the central portion is seen to consist of the yellow ochre, whilst overlying this is a thin film of a dirty white substance, which is the hydrated oxide of alumina. The bottle contains the whole of the alumina which has been precipitated chemically in order to shew the amount present, that is, qualitatively.

With a view to proving that such a change as the one I have just described is probable and can take place, I prepared some persulphite of iron (basic) with which I placed some precipitated and well washed hydrated oxide of alumina. After allowing it to stand for some time I found that some of the alumina had passed into solution, whilst the iron had been precipitated as the buff-coloured oxide; in fact the whole of the iron was completely removed from solution.

The change in the deposit from one of hydrated oxide of iron to one of hydrated oxide of alumina points to the existence of a deposit of alumina, and probably as a bed or layer of the mineral bauxite $Al_2O_3 2H_2O$.

Since writing the above I have revisited the place, and find that the water is now again depositing hydrated oxide of iron. Visit on August 1st, 1902.

Mr. J. DICKINSON, F.G.S., in moving a vote of thanks to the President, said he could not follow him through all the natural changes which appeared to have taken place in this water, but he might just mention that in the North of Ireland a remarkable change takes place in the iron-ore bed, which is extensively worked, and which in certain parts of the district changes gradually into alumina, and is extensively worked under the name of Bauxite.

Mr. HARRISON seconded the motion, which was adopted.

Mr. STIRRUP, F.G.S.: I should suggest that probably there has been some underground change in the water-course, whereby the water has come into contact with the alumina which has been re-deposited. That is a very common occurrence with these underground waters.

Mr. W. SAINT said the theory advanced by Mr. Kinahan to account for the Bauxite deposit in Ireland was that in all probability the bauxite was deposited on the margin of a lake, and that a large proportion of the iron was leeched out of it by the vegetation which grew upon it.

The PRESIDENT: There is no doubt the water is passing over a different bed.

Mr. STIRRUP: We have had some interesting communications on the subject of bauxite. It is a subject not by any means exhausted, for of late years much of the mineral has been found, and it has been discovered in different parts of America.

The following Paper "On Indian Mines and Mining People" was read by Mr. JAMES GRUNDY, H.M. Inspector of Mines in India:—

INDIAN MINES AND MINING PEOPLE.

By Mr. James Grundy, F.G.S., &c.,

H.M. Inspector of Mines in India.

Introduction.

The Society's Secretary, Mr. Saint, has persuaded me to believe that some account of Indian mines, mining, and of the people who work in the mines, will be of interest to the Society. This is my reason for venturing to bring before the Society the subject which, although it is of the very greatest interest to myself, has appeared to me to be of somewhat doubtful interest to other of the Society's members. But I console myself with the feeling that, if I fail to be interesting, I may still count on the Society's usual courteous consideration.

Geological Aspect.

I do not intend to say much on the geological aspect of Indian mining. Much is known of the geology of the mining districts, but it is very desirable that we should know much more, and especially that more attention should be given to the correlation of the strata in the various coal areas; the amount and direction of the dips; the exact positions of the larger faults, and their varying sizes as they pass from area to area; and, perhaps, more especially of the comparison and correlation of the numerous coal seams.

Coal Mines.

The bulk of the paper will have reference to coal mines principally.

Weights, Measures, and Values.

I may also say here that I have tried to reduce all weights, measures, and values, into their English equivalents, so that they may be the more readily appreciated.

The Mines.

The minerals are got out of the earth by levels, quarries, excavations, inclines, and shafts.

Levels.

The Mayo rock-salt mine at Kewrah, in the Punjab, is a very good example of the levels. The rock-salt at this mine is worked under a hill, the seams of good rock-salt amounting to hundreds of feet in thickness, and the levels driven in the seam extend to a distance of over 1,500 feet. The working chambers are on each side of the levels, and are about 40 feet wide, with pillars of solid rock-salt about 25 feet thick between each chamber. The levels are driven, approximately, along the strike.

Quarries.

In some of the coal areas the top seam is so near the surface that it is most convenient to work out the coal by open work.

There is one such seam in Bengal 90 feet thick, of fairly good quality coal, that has been worked in the form of a large quarry for many years.

Excavations.

What I mean by excavations is best illustrated by the mica mining in Hazaribagh, Bengal. When such a so-called mine is being worked on the mica bearing vein they begin, *and continue*, to work where they think the most good mica can be found, and they go on working downwards, and laterally,

so far and in whatever directions appearances of good mica may guide them, so that the depth, direction, size, shape, &c., of these so-called mica mines depends almost solely on appearances and speculation but little, if any at all, on mining or scientific principles, and the longer the favourable appearances continue, or the perseverance of the owner exists, the more the shape and size of the mine baffles accurate description.

Inclines.

The inclines are of very varied shapes, sizes, and inclinations. At a great many the coal is carried out along, or up, the incline to the surface; and many are so steep, especially along the length between the surface soil and the floor of the coal seam, and are so slippery owing to the constant traffic of the women's bare feet along the hard and wet floor, that it is sometimes neither easy nor safe to go along them with boots on.

At a number of the best mines the coal is brought out of the inclines by steam engine and wire rope haulage. When this is the intention the inclines are usually driven down the dip of the seam and extended as the working extends.

There is one haulage incline in Baluchistan—steam engine, and modified main and tail rope haulage—that has an angle of inclination greater than 50°. And there is a haulage incline at the Kolar gold mines about 1,600 yards long, that dips pretty quickly.

Some of the inclines have an area as large as 8ft. × 8ft. and 8ft × 10ft.

Shafts.

The coal mine shafts in India may be described as vertical, of various shapes, and not lined as a rule with either bricks or any other material, except along the distance

passing through the soft surface earth. In a great majority of cases a hard grey sandstone rock is found at very moderate depths, and this rock, with some variations in its texture, usually continues down to the coal, or to within a very short distance of the coal. It follows, therefore, that the shafts have strong natural or rock sides, and that a large number of the seams have a strong rock roof.

Shape of Shafts, and Sizes.

Round. The round coal shafts vary greatly in size, between 6ft. and 17ft. diameter.

Rectangular. The rectangular shafts vary a great deal in size also, but a common size is about 6ft. × 17ft.

Oval. Oval shaped shafts are greatly favoured, and used, by the Superintendent of one of the largest collieries in India as offering a combination of strength, and space convenient for pumps, &c. These oval shafts are of varied sizes, between diameters of 7ft. × 10ft.; 7ft. × 14ft.; 13ft. × 15ft.; and 13ft. × 19ft.

Depths of Shafts.

Coal mining in India has not yet been carried on at any great depth, and there is coal at moderate depths sufficient to last for many years, and to make it little likely that coal mining will be carried on in India at such depths as are now common in this country for a very long time. The depths of shafts at coal mines are probably included between 30ft. and 700ft. deep; and there are only a few deeper than 400ft. The gold mines, as a rule, are much deeper than the coal mines.

Seams of Coal.

The coal seams are usually what would be called thick, even very thick, in this country, for 12ft. thick, 16ft., 18ft., 20ft., 25ft. and upwards, to over 35ft. are not at all

uncommon. It will, of course, be well understood by the mining members that many of such thick seams present many difficult problems in working, that are peculiar to themselves, as well as many advantages. The coal is generally strong or hard, it has the ordinary cleavage planes and faces as prevails with English coals, and it often has slippery and sooty inclined faces running through the seam.

Faults, and Dykes.

The seams are, apparently, only split up by faults at moderate intervals. But there are some large faults which split up the coal areas into sections, and the principal of these faults appear to have a nearly east and west direction. There are also various trap dykes running through the seams of coal and strata, and they are of rather frequent occurrence, and of varying thicknesses and directions, and have burned coal or "Jama" adjacent to them on each side. They cut out but do not displace the seams, and they are usually composed of very hard rock indeed, and very fully make up in trouble and expense for the comparatively small number of faults that displace the seams.

The coal seams appear to lie in detached patches or isolated areas, and at very even distances from the surface.

Quality of Coal.

I do not think there is any coal being mined in India which is equivalent in value to the best English or Welsh coals.

Although much of the coal undergoes a course of selection, both below ground and at the surface, there is very little done in the way of cleaning and screening; and what can really be called mechanical screening is almost entirely absent. The screening of coal at the Indian mines consists of a rectangular and portable screen about $4\frac{1}{2}$ ft. $\times$ 7 ft. area, with meshes or holes about $\frac{1}{2}$ inch square; this is fixed up at

an angle somewhere about 60°, and the coal is thrown at this sloping surface, the small coal that falls through the screen is 'slack,' and the portion that slides down the front of the screen is loaded as 'coal.'

Some little of the coal, *i.e.*, at some of the mines, is tipped directly into the railway wagons; but the great bulk of the coal is loaded into the very inconvenient railway wagons *for purposes of carrying coal*, (they are mostly closed wagons, or vans or trucks) by men and women who carry it into those receptacles.

Many of the coals are rather liable to fire spontaneously, so that underground fires are not at all uncommon; and I know of several mine fires that have been burning persistently for very many years, notwithstanding long continued efforts to extinguish them. And I know of one old, or long continued, fire that has been completely flooded or drowned by a river for many weeks at a time, and at least once every year; but it still continues.

Speaking generally, there is not much coal being worked that is of a really good coking quality.

Nature of Roof.

In very many cases the roof immediately above the coal seam is hard sandstone rock, but in other cases there is a shale above the coal varying from a few inches to several feet thick. The sandstone forms a very sound and good roof as a rule, but it is frequently found that the under surface of the rock developes "papra" or scales when exposed to the weathering effect of damp air for some time, and has to be frequently examined by the "Chāl Jhāru" or roof sweeper, the roof examiner, who goes along the high passages of the mine with a "Sulfi" or "Bunter," which is a long examining pole shod with iron at one end, and with this he

sounds and examines the roof regularly, and causes the dangerous rock scales to fall.

The shale roof, where bared by all the top coal being taken down, is much less secure than the rock roof, and requires to be timbered, and both long poles (props) and chocks are used for this purpose. But the miners, *i.e.*, the coal cutters do scarcely anything at all to secure the roof or sides of the mine or their own working places, all the timber having to be fixed by the "Carpenter mistris" appointed by the owners for the purpose.

Systems of Working.

The principal system of working throughout Bengal, and the only system at the native mines is the pillar and stall, or stoop and room. The coal is worked out in galleries of very variable sizes to form pillars of coal of almost all possible shapes and sizes. The most common widths for galleries are 10 ft. and 12 ft., but there appears to be a greater tendency to form square or larger rectangular pillars of a much greater size than has prevailed hitherto.

Sometimes the galleries are driven in the top coal, some in the middle coal, some in the bottom portion of the seam, and some are in steps, this being one method adopted when taking out almost all the coal from floor to roof. Sometimes the roof coal, and at other parts the floor coal is left unworked for a time, and until there may be a more urgent demand for coal, or the miners may be particularly anxious to get some "pice" (money) with ease in preparation for a "Pujah" (festival). There are now large areas cut out into galleries and pillars in various parts of the colliery districts, many mines being almost completely cut out in this way.

Pillars are being extracted at many "European" collieries, and the natives are fast copying the system from them and doing likewise.

There are also just a few cases where the mines are being worked on the long wall system, and regular systematic packing carried out, in fact at one mine three seams lying near together have been worked almost as one seam, by a modified long-wall system during many years; they are treated as if they formed three layers of one seam. In this mine nearly the whole of the coal is got out, some of the details being that large pillars are first formed, and then worked out, the workings coming back, uphill, in a series of faces. The three seams are worked separately and alternately, beginning at the bottom and following with the work in the higher portions, the faces in the upper portions following those in the lower at some distance behind. A good proportion of the worked out areas are packed with stone that is quarried on the surface and sent down for that purpose, the proportion of packing in each seam has a definite decrease from one seam to the other rising upwards.

A system that is being very successfully worked at Giridih, in Bengal, is like a modification of the two before-named systems, the pillars being entirely taken out very soon after they are formed. One method is what they call the South Staffordshire system, first working out 5 ft. to 10 ft. of the total thickness of coal over an area of 40 ft. wide and 80 ft. long. They drive roadways, 10 ft. wide, to form the coal in the area being worked into pillars; these pillars are next worked out to small dimensions, still in the bottom portion of the seam, so that they are ultimately reduced to lines or rows of small pillars, three "nobs" in each row, each "nob" being about 6 ft. square. The top coal is supported by timber. Next, five shot holes are put into each "nob," with ten ounces of dynamite in each hole; the timber is withdrawn from the top coal, the shots fired, and the "nobs" and all the top coal are thus brought down. All this broken

work is done backwards towards the shaft. This system is being carried out with safety because there is such an excellent rock roof that the loose coal can be taken away from under the high and unsupported rock roof of large area.

The pillar and stall system is also extensively carried out at these same collieries in seams that are not suitable for the other system. The pillars are made 20 ft. × 60 ft., 20 ft. square, also 40 ft. and 60 ft. square, and 60 ft. × 100 ft. Roads, 10 ft. wide, are driven from 6 ft. high up to the height of the seam, sometimes in the top, and at others in the bottom coal. The pillars are worked out coming back. The mine is divided into districts for coal cutting purposes—not for ventilation. When working out the coal the floor coal is first taken up in the galleries, and then the pillars are worked out in sections from the roof downwards. All the slack is raised at these pits.

Firedamp.

There is very little firedamp found in Indian mines, though undoubtedly it often exists, and there have been numerous small accidents and deaths from its explosion. Until I went to investigate there was a general tendency to believe that Indian coals did not give off firedamp, and that the accidents had been brought about by other causes—the explosion of "kerosene oil vapour" being put forward as the most probable. But some precautions are now taken to avoid any bad effects from *firedamp*.

Gunpowder and other Explosives.

There is very little explosive used for actual coal getting. Of course gunpowder ("country powder") and dynamite are largely used for sinking and tunnelling work. The shots, in sinking pits, are usually fired electrically. "Country

gunpowder," *i.e.*, a coarse powder made by the natives near to hand, is extensively used for loosening the rock-salt in the salt mines and quarries; also dynamite, with detonators, at the mica mines; and dynamite, blasting gelatine, gelatine dynamite, &c., at the gold mines.

Machinery, and Haulage.

The system of having the coal carried on the heads of females, and sometimes of men, and generally in a "tokri," or basket, may almost be described as the *standard system* of haulage. But, generally speaking, there is a great deal of machinery in use, and the quantity is fast increasing. It takes the form of steam winding, hauling, pumping, and air compressing engines, and also for generating electricity for electric lighting, coal cutters, and drills. But, as may be guessed, where there is such an excellent and cheap standard system of human haulage, we could not think of being dependent on engines, so that for sinking a mine shaft it is often thought to be sufficient to fix two posts into the ground, the upper ends leaning over towards the shaft, and a crossbar at top holding a 12 inch pulley, to form a complete sinking headgear; and from 30 to 40 females singing curious native village songs, and pulling at a hemp rope as they walk backwards and forwards along their towing path, form what is often considered an excellent source of power for winding men and materials up and down the sinking shaft as far as about 100 feet deep.

The use of "whims," worked by from 20 to 40 females, for winding at a colliery has not been at all uncommon.

However, I think I can truthfully say that very great improvements are being made on the above methods at a quick pace, and that there is very much to give reasonable hope that improvements on the old and crude systems will keep a fair pace with the development of mining in India.

Necessity is often said to be the mother of inventions, and I am sure it is very often the parent of skilful, though sometimes crude, *adaptations* in Indian mining methods. The owners and managers of mines have to get most of their machinery from England, or at any rate out of India; for, though there are some good engineering firms in the large Indian cities they cannot, or do not, supply all that is required at mines, so that it is a very great inconvenience, as well as costly, to have to import or buy imported winding and haulage ropes, engines, pumps, coal tubs, rails, &c.

Persons Employed.

I am not in possession of the most recent figures as to persons employed, output, &c., but the following will probably be of interest.

NUMBER OF PERSONS EMPLOYED IN AND ABOUT MINES IN INDIA IN THE YEAR 1900.

	Coal Mines.	Gold.	Mica.	Other Minerals.	Totals.	
Below Ground—					Below Ground.	
Males	44,463	13,413	2,494	1,129	61,499	Males.
Females	17,206	—	2,100	650	19,956	Females.
Total Below Ground..	61,669	13,413	4,594	1,779	81,455	Males & Females.
Above Ground—					Above Ground.	
Males	18,338	9,906	3,553	4,422	36,219	Males.
Females	10,402	1,707	1,370	1,975	15,454	Females.
Total Above Ground..	28,740	11,613	4,923	6,397	51,673	Males & Females.
Grand Total ..	90,409	25,026	9,517	8,176	133,128	Total.

The foregoing figures include 24,587 persons employed in and at the Mysore (Kolar, and other gold) mines.

Owing to the difficulty, so far, of obtaining complete statistics the above figures cannot be said to fully represent all that are employed at Indian mines. Nor do they include any of the persons employed at quite a number of iron, stone, clay, and other mines.

It may be worth while to point out that *no* females are employed below ground at the gold mines.

Also, that there are upwards of 17,000 females employed below ground at the coal mines; or a total of about 20,000 females employed below ground at all mines. The young children are not, of course, counted because they are not workers.

The number of employees at the mines has been continually increasing.

Output of Minerals.

OUTPUT OF SOME OF THE MINERALS FROM INDIAN MINES FOR THE YEAR 1900.

		Approximate Value. £
Coal	6,095,428 tons	1,339,684
Gold	497,993 ozs.	1,885,675
Mica	916 tons	——
Iron about	59,620 „	9,800
		3,235,159

It may be noted that the value for the gold and that for the coal are not very dissimilar. Also that the total value, amounting as it does to nearly £3,250,000, is not at all an inconsiderable amount; nor does this even approximately represent the total value of the minerals mined, because the figures for numerous other minerals than the above could not be obtained.

The output of coal is fast increasing, an increased quantity is also being used in India, and the export trade of coal from Calcutta is now somewhere near half of the total output.

There is a great quantity of coke, of varying qualities, regularly made; and there are also two or three briquette plants at work.

It should also be noticed that there were 61,669 persons employed below ground in coal mines for 6,095,428 tons, which works out at less than 99 tons per person employed below ground for the year.

Situations, Number, and Output of Mines, and Persons Employed.

I do not propose to give particulars of every little mine and work that might pass under the name of mine.

Year 1900. Kind.	Situation.	Number of Mines.	Output. Tons.	Persons Employed.	Remarks.
Coal	Assam	6	216,736	1,350	Mostly one large firm.
	Baluchistan	9	23,281	625	Small mines.
	Bengal	238	4,954,965	74,030	Most, and biggest, mines.
	Burma	1	10,228	246	
	Central Provinces	8	173,115	1,926	About three collieries.
	Central India	1	164,489	2,214	
	Hyderabad (Deccan) ..	5	469,291	8,045	One large colliery.
	Punjab	2	74,083	1,826	
	Rajputana (Bikanēr) ..	1	9,240	147	
	Totals	271	6,095,428	90,409	Below and above ground.
Mica	Bengal	101	429	5,366	In Hazaribagh.
	Madras	30	487	4,151	
	Totals	131	916	9,517	
			Ozs.		
Gold	Burma	1	1,236	120	
	Hyderabad (Deccan) ..	5	2,473	319	
	Mysore and Madras ..	..	494,284	24,587	Kolar, &c. (Madras four).
	Totals	..	497,993	25,026	

"Deccan" means South, and it is used to distinguish the Native State of Hyderabad which is in the South of India from the Hyderabad which is to the north of Bombay.

It will be noticed that the great majority of the coal mines are in Bengal; and that most of the gold comes from the Kolar mines in the Native State of Mysore.

The coal is mined from quite a number of isolated coal areas, spread over a large area. The nearest mine in Bengal is about 120 miles from Calcutta, and the furthest more than twice that distance away.

There are also slate mines in Bengal. Mines of corundum, graphite, magnesite, and manganese, in Madras. Graphite is also mined in Travancore; salt in the Punjab; rubies, sapphires, and spinels in Burma.

OTHER MINERALS.

	Year 1900. Output.	Valued at about £
Amber (Burma)	9 cwts.	102
Jade „	1,788 „	10,893
Tourmaline „	73 lbs.	1,240
Diamonds (Central India)	169 carats	758

Progress in Indian Mining.

The Indian Mining Association stated, in 1894, that the output of coal was then 1,300,000 tons. If those figures applied to Bengal alone, the increase of output in that Province had increased to 4,955,000 tons in 1900, or nearly four times more than it was in 1894.

Again, the same Association stated that the total number of persons employed in and at mines (coal mines) in the year 1894 was 22,747, whereas the returns showed that the number of persons employed at the coal mines in Bengal for

the year 1900 was 74,030, or about 3⅓ times the number employed in 1894.

The Association also said that, practically all the coal raised in India in 1894 was used in India, whereas we have shown that the output has been greatly increased, and that about half the total output for 1900 was exported from Calcutta. This export, to a great extent, means from one part of India to another part of the same country.

Accidents.

ACCIDENTS in 1900 (exclusive of Mysore) :—

	Accidents.	Deaths. Males.	Deaths. Females.	Deaths. Totals.
Underground ..	53 ..	62 ..	7 ..	69
Surface	3 ..	3 ..	— ..	3
Total	56	65	7	72

Minerals.	Years.	Death rates per 1,000 persons employed.
Coal	1899	1·32
	1900	0·69
Mica	1899	0·26
	1900	0·84

Causes of Accidents.

There were no accidents in the above quoted years from explosions of gases; nor any person suffocated by gases; but there were three accidents, causing the death of six males, by explosives.

Falls of stone and coal caused about half the total accidents and deaths. And 49 of the total accidents in 1900, or 87 per cent. of the whole and causing 62 deaths, occurred at coal mines.

At this place, considering the amount of interest that is now being taken in England on the question of timbering, I may be allowed to quote a short portion of what I recommended for Indian mines in 1894, with a view to increasing the safety of working.

"An ample supply of suitable timber should be constantly "kept in a suitable and convenient place at the mine."

"The timbering, as to kind, general position, distance "apart, &c., should be fixed according to some general rule "as set forth from time to time in writing by the manager, "as being in his opinion the most suitable for the existing conditions."

I am also very glad to be able to say that I have found Indian mine officials, both European and native, ready to profit by any help and advice that they may think is likely to be of advantage to them or their mines.

Characteristics of the Mining People.

I propose to give a few particulars of those sections of the Indian people who work in the coal mines, to show some of their distinctive characteristics, as well as what the people are like. I think they will give a fairly good idea of the mining people in general for they were obtained, along with other information, to give an idea of what would be good and what bad for them, what would be opportune and what inopportune, as well as the effects that would be likely to follow any proposed changes.

The habits of life of Indians, as represented by the mining people, are very simple indeed, and most things that are necessary to the life and well-being of Europeans are quite unnecessary to the natives. They were pithily described to me, early in 1894, by an old and experienced fatherly priest, who said: "They are people who rely on the sky for

a 'topi' (hat), the sun for heat, the ground for a seat and bed, and the fingers for a spoon, knife and fork. Many only clothe themselves, even with the morsel of clothing they use, because the law compels them to do so; and if you give them a chair to use they literally sit *on* it with the whole of their body including their feet on the seat, much in the same way that they sit on the ground."

Even the Babus and others who are looked upon as being high up in the social scale, either sit on their heels with the knees up to the chin, or cross-legged like a European tailor, whilst doing such work as writing, and support the paper or book on the floor or on their legs; and even if the writing material is on a flat table they will then sit on the table, if possible, in the same way. This is also the way, bare-footed and with the feet on the seat, that they travel in railway carriages.

It is the general and common custom of the country, even a dealer in a native shop or at a bazaar stall will sit *on* his stall or counter right in the midst of the fruit, grain, food, or anything else he may be selling, and he leaves no more space to sit in and for all his movements than would be occupied by a small box or basket. It will be readily understood from this that sitting in their own peculiar way is their favourite position both during work and play; that they are able to do anything that is within their reach or reachable by a peculiar shuffling motion by which they move about when in the customary sitting position; and that they do not stand up to do anything whatever if they can do it, or are allowed to do it, sitting down.

Not only is there a great deal of actual mining work done in the sitting position, such as shovelling coal and filling coal tubs in thick seams, but the colliery carpenter will use his plane and other tools, and do almost the whole of his

work sitting. Even if you have a gardener he will delve and weed your garden, &c., and sweep the lawn, almost without once rising from the sitting position, unless you manage to stir him up to greater activity. In short, the native likes to be able to do his work whilst sitting, and will readily move about doing so whilst retaining that position.

It is also, at first, curious to see how many can use their feet for some purposes almost as well as their hands.

Clothing.

The men in the mining districts of Bengal are able to exist with the smallest amount of clothing habitually worn by any of the human race. What they do wear is cotton fabric of varying texture, and it is, in the case of the females, put about their bodies in an elaborate series of folds, almost covering them from the head to just above the feet, and without any stitching, pins, buttons, hooks or eyes, or tapes; and they neither wear stockings nor the bulk of them any shoes.

Very many of the mining men wear only a small piece of cloth fastened about their loins with string; a female's "sári" (cloth by which she is covered from head to feet) would make all the clothes that would serve several of the men for a lifetime. They can, of course, all dress elegantly when they have the means for doing so, and especially when anxious to show themselves off in holiday attire.

Influence of Religion and Caste.

Religion and caste influences and dictates the practices and observances of daily life to a much greater extent than does Christianity in European countries. Hinduism is especially distinguished from all other religions by the degree in which it penetrates into and regulates the social relations and

domestic habits of its adherents, and also by the rigour with which it enforces its decrees.

It regulates marriage, food, and drink, both as to time and manner of eating and drinking, by whom it is cooked and served, and the kind of vessels to be used, as well as with whom it shall be or shall not be taken; also as to kind of work they may perform, and many other things.

The high caste Hindus must not even be touched on any part of the body by any person whatsoever whilst they are eating; nor the shadow of a lower caste Hindu, nor Musalman (Mahommedan), nor Christian pass over their food; if any such thing happens the food is not eaten by them, and the containing vessel is either destroyed or kept out of use as unholy until properly purified again. Nor must anything discarded from the mouth or unfit to eat (an orange pip, for instance, if it has been in the mouth) be allowed to touch the orange or anything else to be eaten, or the plate containing it; if it does, the whole must be destroyed or left for a person of lower caste. It is perhaps worth noting that there is no proselytism in the Hindu religion or caste; everyone is born to his caste whether it is high or low, as is the father, so must be the son or daughter; and no one can really become a Hindu that is not born of Hindu parents, *i.e.*, the mere belief in and practice of the Hindu religion will not make a Hindu.

Castes.

The next few paragraphs represent the opinions of several respectable native mining officials on Indian mining people.

The castes that will work as coal cutters are the Bauris, Sonthals, Keoras, Dhangars, Haris, Chamars, Musalmans, Domes, Moshus, and Bhooas, and occasionally the Rajputs when of low caste. As to some of these names I may well explain that the Sonthals are a caste of aboriginals from

certain hill districts of Bengal. The caste work of Keoras is as swine-herds. Haris are sweepers; Chamars are shoemakers; Rajputs are mostly soldiers, messengers, and such like; Domes are basket makers, they are a very low caste who do most of the work connected with the lifting and moving of dead bodies whether human or brute, and they also act as sweepers. It will be noted that the castes that will work at mines are generally of the lowest order. A real Rajput would neither work as a coal cutter nor condescend to plough land. There are a great variety of low and moderately low castes that work in the mines, and that will work at coal cutting, though all mining men will not cut coal. I think there are at least ten or twelve castes that will work as coal cutters, but the majority of coal cutters in the Bengal mines are Bauris, Sonthals, and Khols.

The Bauris.

Bauris are said to be a dirty class of people. Bauris and Sonthals can be distinguished from each other by appearances and by language. Sonthals are blacker in colour and stouter in build than the Bauris. Bauris, Sonthals, and Domes allow their females to work in the mines, but Domes only seldom. Rajputs, Bhooas, and Rajoars do not allow their wives or daughters to go into the mines, even if they themselves cut coal; nor would they allow any of their females to go into the mine or even to work on the surface at a mine; the same applies to the Musalmans.

There is no objection for any caste to go down a pit, but they do object to the kind of work they are required to do. The Bauris do not, as a general rule, take young children into the mine. Bauris marry early, even as young as nine years of age, and the females go to live with their husbands when as young as thirteen years.

Sonthals.

Sonthals marry not younger than about sixteen years, and go to live with their husbands as soon as they are married. Sonthals will take their children and their whole family into the mine, and shut up the house; as compared with the Bauris they are more suspicious of their wives, like to earn more money, and are more brave. On the whole, when properly understood by the mine officials, they make quite the best coal cutters and miners generally. They are open-hearted but more stupid, and not so cute as the Bauris.

Female Workers.

Women are good workers, and work with a better heart than the men, and are less lazy. Taking all the work that a working mother has to do during the twenty-four hours, she probably does much more work than the man. When women do not go with their husbands to work—widows and others—they work in gangs; and the work is principally pit-clearing or filling out "dust" (slack). They seldom work alone, and one woman would not go to work alone with any man other than her husband or a near relative. They work either in gangs, or with their own families or relatives.

Children.

Women generally take their children with them into the mines, because there is no one else to take care of them; when they have children old enough to look after the little ones they often leave them at home.

Miners' Houses.

The conditions of the mines are said to be better and healthier than many of the miners' houses, for they live, cook, sleep, and do everything inside the one small room that goes by the name of a house. The ordinary miner's

house has only an area of about 10 ft. × 8 ft. up to 10 ft. × 12 ft., and 5 ft. high at the walls, rising up to 10 ft. at the centre ridge. The walls are generally made of dried mud or clay, but sometimes of bricks. The roof cover is straw and bamboo, but sometimes the roof is of "khupra," or tiles.

Character.

The mines of Bengal are within the tropical zone, and the character of the native inhabitants is in many important respects greatly influenced by the geography, productiveness of the soil, and the warmth and moisture of the climate. The people require to be well known to be properly managed, for the climate influences their habits of life, clothing, food, occupations, and the structure of their dwellings. Warm and damp parts make the people inert, feeble, less active and energetic than the people who live in cold and dry parts of the country. This is the opinion of a Mine Superintendent who understands Bengal and its mining people very well indeed.

Stature.

The two following castes are given as fairly representing the whole:—

Caste.	Height. Men.	Women.
Chamars..	5 ft. 4 in.	4 ft. 10 in.
Koeri ..	A little over 5 ft. 2 in. ..	Nearly 4 ft. 9 in.

The average may be taken as somewhere between a little over 5 ft. to about 5 ft. 7 in.

Colour.

The colour of the native miners is of a brownish colour to black, or from the rich light brown of a Goala to the blackish colour of the Masahars and Kholes.

Cost of Living, and Wages.

Food.

In Bengal the food of the miners is boiled rice and dál, fried unleavened bread or thin cakes ("roti"), and curried vegetables; some eat meat and fish occasionally, when it can be got. A man is said to eat daily about 2 lbs. of rice and ½ lb. of dál (lentils). If they have more than two meals in the day, the mid-day repast consists of cold cooked food, or some dry grain, bread, fruit, or sweets, if possible to get such luxuries.

Cost of Food.

A temperate man can live on 1½d. per day, or 4s. per month, for food. The average prices of the kinds of food they eat may be taken as:—Rice, 19½ lbs. for 1s.; dál (lentils), ¾d. per lb.

In addition to the above must be added, for those who can afford, the cost of salt, spices, oil, vegetables, &c.; but an adult native can live fairly well on about 4s. per month for food.

Clothing.

The clothing is not a very large item in the household's expenditure.

Drink.

The drink of all natives is water. And water is so universally thought of, and used, as *the drink*, as well as believed to have medicinal properties, that it is almost worshipped; and many rivers (the Ganges for instance) and other sources of water supply are considered by the Hindús as pure and sacred. But some natives drink something stronger than pure water when they are able to obtain alcoholic drinks. This is especially the case at marriage festivals, because the relatives and invited friends will, as a

rule, only eat when there is something considered good to wash down the food on such merry occasions; yet, on the whole, the natives of India may be considered very abstemious indeed. It is said that a miner can get quite drunk at the cost of from 1d. to 1½d.; and the amount of tobacco costing from a farthing to a halfpenny will suffice for a family for a whole day,—even the young children are taught to smoke. They say that grog is taken to make them feel happy. The rice grog, being the cheapest, is that most generally drunk; it is not so good, or preferred so much, as that made from "Mewah," or fruit, but this kind is much more expensive. A cheap country spirit is distilled from fruits and sold at about 1s. 4d. (a Rupee) per bottle, but this can only be bought by the miners as a very great luxury.

It is worth mentioning that an apparently very successful attempt is being made to introduce the use of tea amongst even the poor natives, and to accustom them to its use; this is being brought about by the sale of cups of tea at the price of a farthing, as well as of farthing packets of dry tea.

Wages.

The amount of wages paid, method of determining the amount, the time of payment, and the periods between the payments, vary a great deal in the different mining districts. As a sample of one of the best may be taken the East India Railway Co.'s Colliery, where "Sirkhari" (Company's) labourers have a daily rate of wages paid weekly. Surface men are paid 2½d. per day, and females 2d. Skilled labour is paid, according to demand, at from 3d. to 1s. 7d. per day.

Miners, *i.e.*, coal cutters, are paid by measure in buckets or coal tubs, at from 1½d. to 5d. per bucket, as determined by the overmen and agreed to by the miner. But at this colliery there is a sort of proviso that "all hard-working coal cutters must get a minimum wage of 4d. per day."

At some mines the prices paid to the miners vary with the distance that the coal has to be carried up to about 8d. per ton. A bucket will hold about 5 cwts. of coal, and the miner may receive 2d. for delivering that quantity at the place appointed, which may be in a shunt, at the pit bottom, or on the surface. A tub of coal may be thought of as about $7\frac{1}{3}$ cwts., for which quantity of coal the miner will probably receive 3d.

Where the coal is carried out to the surface by the miner, or his wife, daughter, or other assistant, it is placed into the miner's own low heap, 1 ft. high, until it becomes 10 ft. × 10 ft. in area, and the rate of payment is then reckoned at so much per 100 cubic feet.

Wages are paid monthly, weekly, and daily, the latter system being somewhat common in parts of Bengal.

Allowances. Rice-growing Land.

In addition to wages there is a great variety of allowances which, whatever may be said as to the desirability of the system, form a considerable addition to the comfort of living. The allowances to miners take the form of free house, coals, tools, oil, various other allowances, and land either free or at a very nominal rental. For instance, each coal cutter may have claim to as much as 2 bigahs of land, so that a family consisting of father and three sons, who are coal cutters, may have as much as 8 bigahs of land on which to grow rice for their food, or say $2\frac{1}{2}$ acres.

One bigah = 120 ft. × 120 ft. = 14,400 sq. ft. or 40 yds. × 40 yds. = 1,600 sq. yds.

Rice being the staple food in Bengal, this is the grain almost universally grown by the miners. The amount of rice that can be grown on a bigah of land varies greatly, but may be taken as about 410 lbs. to 820 lbs., and even up

1,640 lbs. of rice in the year, say an average of about 738 lbs. of unhusked "paddy," which would give about 410 lbs of clean rice. So that the miners often grow as much rice on their land as will keep them with food during some months of the year.

Other matters.

There are very many other matters that might have been referred to, but really something must be omitted from a paper dealing with such a large subject.

Provision for the Needy.

But, in conclusion, let it be noted that in India there appears to be no establishments or charity organizations, corresponding to the English workhouse, Board of Guardians, or other public bodies for relieving the native poor from the rates and taxes, or otherwise. These people are accustomed to do all they possibly can to provide for all their own needy relatives, and to do so is a sacred duty with these people who are so often described as uncivilized heathens.

Mr. J. Dickinson, F.G.S., proposed a vote of thanks to Mr. Grundy, remarking that the paper contained a great deal of interesting matter.

Mr. M. Stirrup, F.G.S.: I have very great pleasure in seconding the motion, because I knew Mr. Grundy as a very hard worker amongst us something like ten years ago. I had heard that he was back here on a short holiday for the re-establishment of his health, which I suppose becomes necessary to all Englishmen who go to reside in India. I think it was a good selection on the part of the Government to take him to India, where he has been able to gather a large amount of information which would be difficult to get

otherwise. I do not know whether he has mentioned anything about the geological position of these coal mines.

Mr. GRUNDY: No.

Mr. STIRRUP: I always understood these Indian mines belonged to a later geological period than those in England. Some of our members have been connected officially with these Indian mines, and we have had important Papers from them years ago.

Mr. GERRARD said he had been greatly interested with Mr. Grundy's treatment of the subject. He was sure they all wished Mr. Grundy a speedy and complete restoration to health, and that he might go back to India to carry on the work he was so capable of doing.

The resolution was carried with acclamation.

The following Paper "On the National Interest in the future Coal Supply," was read by Mr. William Pickstone:—

ON THE NATIONAL INTEREST IN THE FUTURE COAL SUPPLY.

By Mr. William Pickstone.

The following is a letter on the subject written by me to the Editor of the *Manchester City News* :—

"TO NATIONALISE OUR SUPPLY OF COAL."

"Sir,—Another Royal Commission on our coal supplies has been appointed. It is to conduct its inquiry with closed doors—with what object is not too clear. To those who know little about the question it may mean that the object is to keep both ourselves and our Continental neighbours from the knowledge of the probably not distant failure of the supplies.

In my view one result of that inquiry should be to nationalize the supply that remains to us, whether known or unknown. No geologist, I imagine, has any doubt about there being very large supplies that are covered by such a thickness of unprofitable crust as to be of no great commercial value, possibly under the large area of chalk in the South of England, and certainly under the large area of New Red Sandstone in South Lancashire, Cheshire, and parts of North Staffordshire. Both these great fields of coal add nothing to the surface value in the sales of estates either by auction or by private treaty, so that not much, if any, damage would be done to the owners of the land if the State became the

purchaser of the minerals that either may or are known to lie under them.

It is well known to those who are acquainted with the subject that much coal has been left underground in the areas already operated upon, because of some inferiority in the quality that made it unmarketable, except at a loss to the coal-master. It has not often been the case that coal-masters have had a very good time, such as they have had within the last year or two, and good times, as a rule, in any industry are short-lived. For many of them two years of good times have been followed by fifteen or twenty of bad—times when only the best qualities of coal and favourably located collieries could market the article at a profit at the pit mouth. Profit or no profit, the rent must be paid. This sort of inconvenience to the coal-master might not be discontinued under a State ownership, but the personal interest would cease, and that might be more bearable. Besides, the State might prove the coal for the future colliery proprietor, which, as a rule, is not done under private ownership.

I make two suggestions, therefore—that the State should acquire, or take possession, if you will, of all coal deposits in the United Kingdom that have no present commercial value by reason of the depth at which they lie, and that the State take steps, by boring, to find out what coalfields we have.

It may be of interest to some of your readers to know that only one member of the last Royal Commission survives, and that he is still an active member of the Manchester Geological Society."

Having called the attention of Mr. Dickinson and Mr. Saint to this letter, and being encouraged by both of

them to write a paper, elaborating the subject, I came to the conclusion to read the report of the Commission that sat for five years, from 1866 to 1871.

The Commissioners were instructed primarily to investigate the probable quantity of coal contained in the coalfields of the United Kingdom, and to report on the quantity of such coal which may reasonably be expected to be available for use, and whether it is probable that coal exists at workable depths under the Permian, New Red Sandstone, and other superincumbent strata.

The Commissioners were empowered to invite all such persons as they in their judgment might think competent to give correct information calculated to assist them in the execution of the trust "hereby reposed in you." There was no power to command persons to give information,—the limit of power was, "by all other lawful ways and means whatsoever."

The Commissioners set to work; five General Committees were appointed, "each with power to take evidence." The powers given to the Commissioners were transferred to these Committees; they were requested to examine witnesses "by all lawful ways and means," and to report to the Commission afterwards. Two other Committees were appointed; one on maps and one to draw up the general report. A very large amount of evidence was taken by the five Committees and some Sub-Committees, but it was difficult to get in many quarters the information attempted to be obtained by some of them. To circulars sent out asking for information, a considerable proportion were not returned, and estimates of "get" and "consumption" had in many cases to be resorted to in making the reports.

There was an evident reluctance, a wide-spread reluctance, to give information, although there were a few splendid exceptions, one of which was from collieries near to this city. The estimate of "get" in 1869 was 107,000,000 of tons, of which under 11,000,000 were exported. There was found to be a wide difference of opinion among the experts as to the future requirements for both home consumption and exports. Robert Hunt, Esq., of the Museum of Practical Geology, was of opinion, "after very carefully considering the whole subject," that any further increase in the exports was unlikely, and that in our manufacturing industries, including iron and steel, no very considerable increase was likely to occur; while for domestic purposes the increase of the population (one per cent. per annum) might fairly represent the increase of consumption in that direction. Mr. Hunt, it must be understood, was one of the Commissioners and an expert. I need hardly say that Mr. Hunt's estimates have been very much exceeded, and that other estimates that were deemed extravagant have been reached.

The general result of the enquiry was to show that only a small proportion of the known coal measures had been worked out at that time, those nearest the surface having been the ones to take up the attention of coal masters. The Astley deep pit (some 800 yards) was at that time the deepest in the kingdom. In passing, I would just remark that the Astley pit would seem to have been worked for the benefit of the consumers. To one of the Committee was delegated the enquiry as to possible coalfields (workable fields) under the Permian and New Red Sandstone, and the outcome of that was to call the attention of the Committee to the question of coal under the chalk of Kent and those that are called Home Counties. Mr. Prestwich made a strong report

on the more than mere probability of such a coalfield. In this, Mr. Prestwich was strongly supported by Mr. Godwin-Austin, but it was left to our friend Professor Boyd-Dawkins, acting under instructions from Sir E. W. Watkin, to actually prove what the above named gentlemen had given so decided an opinion upon, and I think the Professor was not far out when he concluded his paper read before the Society February 9th, 1897:—"That that new coalfield will add sooner or later a new centre of industrial activity to the resources of this country."

Much evidence was taken about the possible depths at which coal might be workable, and about the probable heat at increasing depths. There was a general consensus of opinion that up to 4,000 feet it would be fair to affirm that coal could be worked, but that at depths below 3,000 feet there might be a considerably increased cost in the getting: but it was also conceded that science might have more to say yet about ventilation, and that other yet unknown helps to accomplish deep mine working might be found.

Now, in face of what has happened since that Commission reported in July, 1871, and of what is going on to-day, and of what seems to be probable in the future, what should be our attitude as a Nation,—the attitude of the men of this generation? Personally, I am strongly of the opinion that the nationalisation of such supplies, proved or unproved, as have no present commercial value to the owners of the land under which they lie, should be one of the outcomes of the newly-appointed Royal Commission. It would be easy to show, without going far from this city, that estates lately sold, having undoubtedly coal in great abundance below them, have changed hands on a simply surface value basis.

I should like to conclude my paper with an attempt to show what, in my opinion, ought to be the outcome of the Nation's control.

No pits should be sunk in any area beyond what would be needed to effectually work out the coal that could be economically raised there.

All shafts should be sized, with the object of getting all the seams of workable coal of the winning.

There should be no conflict of ownership, and therefore no chance of one master having to pump another master's water.

No way-leaves to pay.

No blocks of coal lost by having to leave barriers.

No dead rents.

Live rents should be arranged according to the quality of the coal; its price per ton in the market to be preferred.

Sale prices to be so regulated that coal-masters would be secured fair average profits, and the public saved from the pressure of excessive prices.

A better organisation of labour, with a fair day's wage for a fair day's work, and an eight hours day for miners.

Under such conditions strikes would probably be unknown.

My subject is a large one: I have dealt with it very imperfectly; but such as it is, it will, I hope, go before the

Commissioners with the approval of the Manchester Geological Society.

On the motion of Mr. Dickinson, seconded by Mr. Grundy, a vote of thanks was accorded to Mr. Pickstone for his Paper, and it was agreed to discuss it at a future meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, the 8th April, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

The President (Mr. JONATHAN BARNES, F.G.S.) occupied the Chair, except during the reading and discussion upon his paper. During this period Mr. RIDYARD presided.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were unanimously elected ordinary members of the Society:—

Mr. CHARLES F. BOURCHIER, Strangeways House, Platt Bridge, near Wigan.

Mr. JOSEPH BREWERTON, Civil and Mining Engineer, Ogden's Buildings, 97, Bridge Street, Manchester.

Mr. JOHN HEWITT, Colliery Manager, Belle Green Lane, Ince, Wigan.

Mr. DANIEL LATHOM, Surveyor, Rose Bridge and Ince Hall Collieries, Wigan.

Mr. JONATHAN BARNES, F.G.S., President, read the following communication:—"Further observations on the change brought about by the intrusion of igneous matter into the Carboniferous Limestone at Peak Forest."

FURTHER OBSERVATIONS ON THE CHANGES BROUGHT ABOUT BY THE INTRUSION OF IGNEOUS MATTER INTO THE CARBONIFEROUS LIMESTONE AT PEAK FOREST.

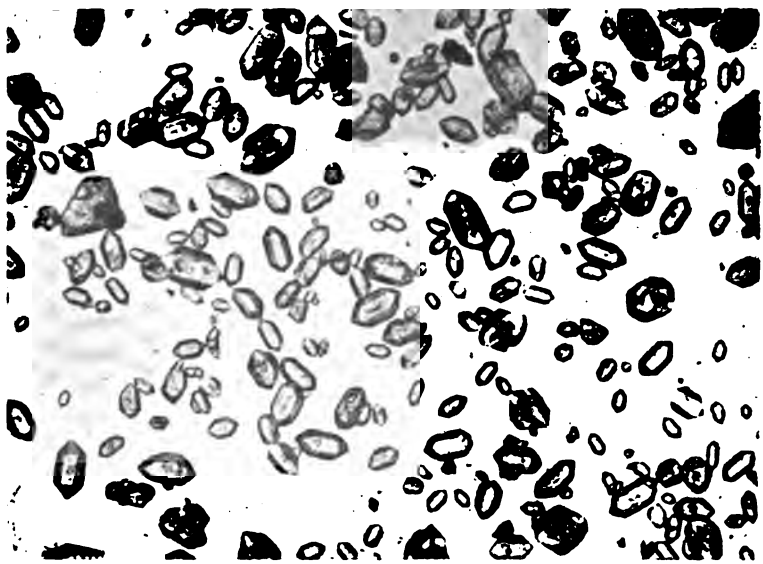
By Mr. J. Barnes, F.G.S.

At the February meeting of this Society I had the pleasure and honour of bringing to your notice the fact that not all the igneous rocks found in the Derbyshire Carboniferous Limestone were of contemporaneous origin, but that some were of the intrusive kind; this is shown by the nature of the igneous rock itself, as well as by the very complete metamorphism of the limestone, which was in contact with the previously highly heated intrusive matter. To-day, I wish to draw your attention to another, and very interesting change, that took place during the period when the highly heated and intrusive material was in contact with the limestone.

Those of you who were present at the meeting held in February will remember that I showed some very beautiful and perfect mecroscopic bipyramidal quartz crystals, which I had extracted from the limestone, *i.e.*, limestone which had not been subjected to the action of heat. These quartz crystals are a very common ingredient in mountain limestone, from the smallest up to those that may be distinguished by the naked eye.

The limestone at Peak Forest, about which I spoke to you, forms no exception to the rule as regards the occurrence in it of quartz crystals, but the crystals are rather exceptional in perfectness, they being well developed, nearly all free, occasionally they are twinned, this of course is in the limestone that has not suffered any changes by the action of the intrusive rock.

From a question put to me by Prof. Dawkins as to whether the crystals still remained after the marmorisation had gone on, I had to acknowledge that I did not know whether the quartz was still present as such, or whether it had united with the lime to form a silicate; it is to answering this question that I have to-day ventured to bring this matter again to your notice.



QUARTZ CRYSTALS FROM UNALTERED LIMESTONE.
Magnified 35 diameters.

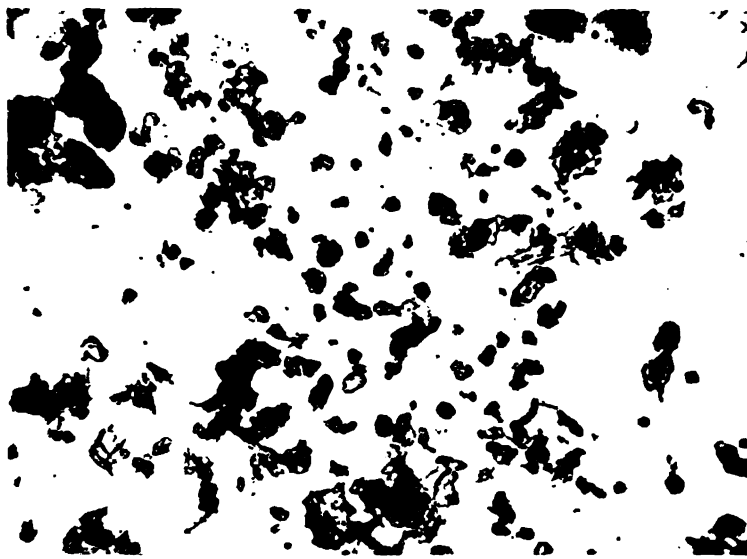
As is well known when lime or limestone is highly heated and in contact with silica or quartz, a very readily fusible compound is formed, consisting of calcium silicate, so that one would scarcely expect to find any quartz crystals in a limestone that has been subjected to such a high temperature as must have been that at Peak Forest, which was in contact with the intrusive rock. However, on treatment with acid, and on examining the residue microscopically,

there are to be seen not the very fine and beautiful crystals, but small corroded portions of former crystals, the apices of the pyramids are almost in every case eaten away, whilst the angles are also not at all sharp, and the size is not more than $\frac{1}{10}$th the original of their former selves. Whilst the hypothesis that it was probable that the quartz crystals would have been entirely destroyed is not quite borne out by the examination, is rather important, inasmuch as it shows that quartz was and is still present, for it would have been easy to argue, had the quartz in the altered limestone been entirely absent, that it had never been present; whilst on the other hand the presence of quartz in partially rounded particles shows that what was expected to have taken place was proved to be the case, viz., that the lime had united with some of silica.

Metamorphosed limestones are of very considerable importance as materials for useful and ornamental purposes, and none more so than the beautiful white marble found at Carrara, in Italy. Now in this particular case, as I showed you last time, it is almost identical in microscopical structure with the metamorphosed Peak Forest limestone. In the Carrara marble, however, the quartz crystals are well developed, which you will perceive is quite the opposite to what obtains in the marble from Derbyshire; and although both varieties, *i.e.*, the Carrara marble and the Peak Forest marble, have the same chemical composition and practically the same microscopical structure, they cannot both have been metamorphosed under the same conditions.

The metamorphism brought about at Peak Forest may be said to be due to a dry heat or Thermo-metamorphism, whilst that which has induced the metamorphism in the Carrara marble must have been due to heat in the presence of water, or Thermo-hydro-metamorphism, and under such

circumstances the limestone would not decompose and afterwards act upon the quartz crystals; in this way their presence in the Carrara marble may be explained.



INSOLUBLE RESIDUE IN METAMORPHOSED LIMESTONE.
Showing eroded quartz crystals and calcic silicate.
Magnified 60 diameters.

Besides the change of the limestone itself and the almost complete removal of the crystals, the bands of chert found intercalated in the various beds have also undergone some change. Chert as you know when newly broken has a colloidal appearance, but the chert in question has a semi-crystalline appearance. The change is however not so complete as in the case of the limestone, and this is what might be expected on account of the more refractory nature of the chert itself.

The PRESIDENT: Now, gentlemen, I shall ask you to look at the sections and to view the microscopic results, and you will see what the changes have been.

Mr. RIDYARD: I think the best thanks of the Society are due to Mr. Barnes for his paper. Certainly, it strikes one forcibly that our President this year is very persistent in his enquiries into these geological matters, and I am sure he is entitled to our heartiest thanks. I move that the best thanks of the Society be given to him for his paper.

Mr. JAMES TONGE: I have pleasure in seconding the motion. I am sure we are under very great obligation to Mr. Barnes for his continual explorations and for the reports thereon brought before this Society, which are most interesting to us.

The resolution was adopted.

Mr. JOSEPH DICKINSON: Our President authoritatively calls these rocks igneous. They may be so. I have worked coal very near the corresponding stratified whin, and it is a fact that as the seams approach they lose a large portion of their volatile matter and become anthracite. But whether that loss is due to heat or to some other cause I cannot say. I can say that, if these beds have been in a molten state, their intrusion must have caused a great commotion—much greater than we find evidence of. Another thing. I have analysed several samples of the rock, and found as much as 12 per cent. of metallic iron and some carbonic acid. If this rock has been in a molten state, how comes it that carbonic acid has not been expelled? We do not find that in blast furnace slag. Mr. Barnes, who is an accomplished chemist, will perhaps give us some explanation of that, and why in some of the places the columnar form is assumed.

The PRESIDENT: I do not quite understand whether the carbonic acid of which you speak is in a combined state or in a free state. Did you obtain it after treatment with acid?

Mr. DICKINSON: It would be probably combined with lime and the iron.

The PRESIDENT: The presence of the carbonic acid is easily explained. It can be found to-day in the igneous rocks. But it was not originally there. Its presence is due to percolation of water containing lime in solution. If you take a freshly opened piece of the rock you will find no carbonic acid, just as none is to be found in the slag of the furnace.

Mr. DICKINSON: Why are the crystals in one case of a very fine texture, and in the floating beds generally of a coarse texture?

The PRESIDENT: The quicker the cooling, the smaller the crystals. If you make crystals rapidly you have them very small. If you make them slowly you have them increased in size.

BLACKPOOL AND THE SUBSOIL.

By Joseph Dickinson, F.G.S.

Blackpool in Lancashire, sometimes called the Brighton of the North, being within easy access from very populous manufacturing districts is one of the most frequented seaside health resorts in the kingdom. The sea is open, the air bracing, the accommodation for visitors plenty, and the entertainments numerous.

Whether it be the ocean current divided round Ireland meeting a little north of Blackpool, or these tides in conjunction with the subsoil, the climate teems with ozone, sending a thrill through all persons strong enough for such bracing air. This phenomenon is the more remarkable inasmuch as Southport and Lytham southwards, and Grange-over-Sands northwards are celebrated for mildness; the Isle of Man westward being famed for general salubrity.

What is now about to be mentioned, however, relates especially to the subsoil and the kinds of stone used in the sea walls and promenades, rather than to the climate.

The covering drift is composed mainly of clay with boulders and a few patches of peatmoss. Underneath are saliferous marls. Some of the boulders are scratched as if by friction in transit from their silurian sources; and at places there are found fantastic aggregations of sand, gravel, and clay, which are gathered as curiosities. The saliferous marls are of the usual variegated kind, with some gypsum and rock salt, the latter and brine being extensively worked at Preesall.

Most of the subsoil is incapable of resisting the force of the sea, which is sometimes very rough. Many of the early

timbering and stone protections have been swept away. Even the later more substantial facings are not always effective. The low ground at Southshore was at first an easy prey. The higher ground at Claremont is somewhat firmer, but on the high cliffs north of the Gynn, landslip is following landslip; the land there having according to tradition receded from the mussel beds, which are now some hundreds of yards off on the foreshore.

Within the last fifty years there stood in a field on the cliff east of the mussel beds a small hut called Uncle Tom's Cabin or the toffy shop, where "treacle claggum" and other light refreshments were sold. The site and surroundings afterwards became covered with brick and mortar buildings, resulting in a licensed public-house and numerous accessories. Now parts of these buildings are slipping into the sea.

Southwards, from the Gynn to Southshore, a distance of two or three miles, substantial sea walls are now constructed, with promenades, roadways and an electric tramway. Through Claremont there are three tiers, consisting of a promenade close to the sea, next above a carriage drive with promenade, and on the top in front of the dwelling-houses a like combination with the tramway. The remainder is single but broad, combining promenade, drive, and tramway. Wide as the latter is it is not considered sufficient for the crowds of visitors, and preparation is now being made for widening. It seems also likely that sea walls will be reconstructed north of the Gynn.

The materials used in constructing these sea walls, roadways, and promenades consist mainly of various kinds of stone, cement flags, and cement. The stone includes some of the local boulders of silurian and granite, also sandstone, limestone, and recently basalt. Most of the variety is from

places far apart. The flags come from Shap, and the basalt from Germany.

The basalt deserves special mention. It is fine grained and columnar, similar to that of the Giant's Causeway in Ireland; and is brought from Bingen on the Rhine. The original columns are broken into pieces about one foot in length suitable for facing the sea walls. Most of the pieces are hexagonal, but varied with a few of five and others of seven sides; the breadth of the faces varying. The diameters of the pieces vary from six to fourteen inches, averaging about ten inches. In their broken state the original length of the columns between bedding partings is not shown; but judging from the larger number of broken ends to that of natural ends the length has been many feet. Some of the smooth natural ends are flat, others are convex with a corresponding concave adjoining.

Before midsummer, 1901, a length of about 200 yards of sloping sea wall south of Victoria Pier had been faced with these basaltic sets, and large heaps were lying near the Gynn ready for use. Those already placed resemble an imitation Giant's Causeway, but minus the exact fitting of adjoining faces and with more broken than natural ends. Now, in 1902, further large supplies of basalt being wanted for the promenade widening, tenders have, it appears, been received, including some from Ireland. Those from Ireland are not likely to include any from the Giant's Causeway, but will probably relate to the coarse thick bedded kinds, or to the huge columns such as those at Fairhead. In fact it appears that cargoes of the fine kind from Germany are now arriving at Fleetwood.

Great hopes are entertained of the durability of these fine columns, and apparently with good cause, judging from those of similar structure at the Giant's Causeway. From the

writer's own experience the fine grained makes very durable road stone, whilst the coarse grained soon crumbles.

The numerous varieties of stone and cement used in forming these promenades and sea walls afford good opportunity of observing the durability of each kind. Possibly in after years, when some of the less durable kinds are weathered away and memory has faded, the source of those remaining may perhaps afford a geological puzzle similarly interesting to that of the cause of the scratchings on the boulders found in the native drift.

The PRESIDENT: I am sure we are very much obliged to Mr. Dickinson for his interesting paper—not very geological. The rocks about which he spoke are full of interest. I expected to have heard something about the action of the subsoil on the atmosphere. With regard to the statement about ozone, I doubt whether there is much ozone in the air at Blackpool. How do you tell, Mr. Dickinson, whether there is ozone in the air there or not? A good deal is said about ozone, but very little is known by the general public. It is very easy to detect when it is present. Anyone with a good nose can detect it.

Mr. PICKSTONE: What does it smell like?

The PRESIDENT: It has a smell peculiar to itself. Nothing I know possesses such an odour. I cannot describe it to you. I know a considerable amount has been developed since electric trams started in Manchester and Salford, so that there will be an advantage in living on a tram route. It has a peculiar smell; you get it after a thunderstorm, but I have never detected it at Blackpool. How does Mr. Dickinson detect it? Or does he take it from the advertisements that are displayed and published for the benefit of the town?

Mr. MARK STIRRUP, F.G.S.: I have very great pleasure in proposing a vote of thanks to our old and highly esteemed member. When Mr. Dickinson gives us a paper it is always interesting. With regard to this paper, I don't know whether it is intended as an advertisement for Blackpool or not, but I should suppose Blackpool is sufficiently well known to Lancashire people, perhaps, not to need any advertisement. But with you, sir, I expected, from the title of the paper, that something would have been said with regard to the geology of Blackpool, which of course is exceedingly interesting. All the same, the facts which Mr. Dickinson has put on paper in reference to the stone which is being used in the formation of the sea defences at Blackpool will, I have no doubt, be very beneficial to those geologists who succeed us, for I know these imported stones have been already a difficulty with some geologists. One man said he had found Shap granite there which he presumed had come from the boulder clay cliffs. Now, it has been pretty well ascertained in years gone by that there was no Shap granite to be found in the boulder clay hereabouts, but Shap granite has been imported for the purpose named by Mr. Dickinson, namely, the buttressing and protection of the cliffs, and when many of these great pieces of rock have been washed and worn by the action of the tide, and torn from the embankment, strangers will probably come along and say that they must have come from the boulder clay. The facts, therefore, which Mr. Dickinson has here recorded, will prevent such a false idea with regard to the source of this stone. It is new to me, the statement with regard to the basalt being imported to Blackpool from the Rhine. When I was at Blackpool last, some years ago, I do not remember seeing anything of that basalt. For how long has that basalt been imported for the purpose you have named?

Mr. PICKSTONE: The importation is quite recent.

Mr. STIRRUP: When I go to Blackpool I take a ramble to see the great wasting of the cliffs which is going on. I remember Uncle Tom's Cabin, and anyone who has known Blackpool for the last thirty or forty years will be quite cognisant of the great destruction and falling away of those cliffs on the northern side of the town. Mr. Dickinson has mentioned the basalt and the granite, but I do not remember seeing any but the Shap granite blocks. Of course a good deal of the sea wall is made up of the concrete slabs, but these Shap granite blocks were used near the Gynn when I saw them for a portion of the Promenade, and it is rather curious to me that they can import basalt from Bingen on the Rhine and supersede home materials. I would like to know how they come.

Mr. PICKSTONE: They are floated down the Rhine.

Mr. STIRRUP: Where to?

Mr. PICKSTONE: I don't know where they are loaded, but they do come from there. They have cheap rates of carriage in Germany, one-tenth about of ours.

Mr. DICKINSON: I inquired at the Corporation's offices where the stone came from, and was told it came from Bingen.

Mr. STIRRUP: It is rather wonderful they should bring stone so far, when they could have got it so much nearer home, from Ireland, Scotland, or Wales.

Mr. PICKSTONE: Not the same rock. It is self-hewn rock.

Mr. STIRRUP: You have the selfsame basalt rock just across in Ireland.

Mr. PICKSTONE: They will not allow it to be taken from the Giant's Causeway.

Mr. STIRRUP: There are plenty of other places on the Antrim coast where you can get it—at least I presume you can—without touching the Giant's Causeway.

Mr. PICKSTONE: I beg to second the motion. I am glad to find that Mr. Dickinson, who not long ago charged me with writing poetry in my paper, is himself worthy to be put in the rank of poets. I am very glad that both he and I, at our respective ages, can put a bit of poetry even in a scientific paper. I should like to have had some information respecting the underlying rocks under that clay at Blackpool. I don't know whether Mr. Dickinson knows the red sandstone is underlying there or not. I think it is in many places not many miles away. Why is there not a coalfield there?

Mr. STIRRUP: They have bored for coal there.

Mr. PICKSTONE: At Blackpool?

Mr. STIRRUP: Yes, but it was too deep. They got to a certain distance and then gave up the task.

The resolution was passed.

Mr. DICKINSON: My thanks are due to you for the vote of thanks. As to the insinuation that my paper is in some sense an advertisement for Blackpool, I have only to say I have no interest in Blackpool except that it is a fine health resort. We had in this Society some years ago a very celebrated chemist, whose name now is a household word through the manufactures that are still carried on in his name—I mean Mr. Crace Calvert. Mr. Calvert told me on one occasion that, having worked in his laboratory so sedulously, his health gave way, and he consulted a physician, who said to him, "Sir, nothing will save your life except going on the Continent for three years and taking perfect rest." Mr. Calvert replied, "You may as

well condemn a professional man to death as tell him he must go away for three years on the Continent and give up his practice." "I went," Mr. Calvert said to me, "to Blackpool. There was a sea breeze blowing. I stood on the sea shore. I inhaled it all, swallowed the ozone"—he called it ozone in those days—"and in a few days I came back a restored man." Mr. Calvert always went to Blackpool after that, and he lived for about twenty-five years after he told me the story.

This concluded the business of the meeting, but before the members separated, Mr. Stirrup gave an account of what took place at the recent meeting in the Town Hall of representatives of Manchester scientific societies, touching the question of the desirableness or otherwise of having a central building in which all the societies could be housed and have their meetings.

After much discussion, a committee was nominated, with power to add to their number, to consider the question at a future meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, May 13th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. JOSEPH DICKINSON, F.G.S., in the absence of the President (Mr. Jonathan Barnes, F.G.S.,) in the Chair.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were unanimously elected Ordinary Members of the Society:—

Mr. WALTER T. GARTON, M.E., Worsley House, Worsley Mesnes, Pemberton, near Wigan.

Mr. S. SALISBURY, 29, Blackfriars Street, Manchester.

Captain ARTHUR WALL, Coed Mawr Hall, Tal-y-Cafn, Wales.

Mr. ALFRED J. TONGE read the following paper "On the Erection and a few tests of a Turbo-Ventilating Fan and Generator at Hulton Collieries," illustrated by lantern slides:—

ON THE ERECTION AND A FEW TESTS OF A TURBO-FAN AND GENERATOR AT HULTON COLLIERY.

By Mr. Alfred J. Tonge.

It will no doubt render the subsequent remarks more interesting if I state briefly the conditions of the ventilation and the position of the shafts prior to the erection of a turbo fan in June last.

The seams that required some additional ventilation were known as the Deep Arley and Two Feet.

The Deep Arley mine was 260 yards and the Two Feet 70 yards deep at the downcast shafts.

The ventilation of the two mines was entirely separate, each mine having its own pair of shafts.

The workings in each case were on the dip side of the shafts. In the Deep Arley the average length of air-ways in the different splits was 5,000 yards, and the average total quantity of air circulating was about 20,000 cubic feet per minute, while in the Two Feet the average length of air-ways was 3,000 yards and the quantity of air circulating was about 10,000 cubic feet per minute. The water gauge, as shown at the separation doors underground was in each case about ·5 of an inch. The Deep Arley downcast shaft was however some 700 yards distant from the upcast shaft, and this frictional resistance was not ascertained. The shaft friction in each case was not ascertained.

It was thought advisable to at least double the quantity of air in the workings of each mine, and as the water guage would be increased considerably and the consequent escape greater it was considered that at least 80,000 cubic feet of air per minute should pass through the proposed fan. The

anticipated water gauge under these conditions was about 4 inches. An allowance for future extensions was also made, the ultimate anticipated water guage being 6 inches. In order to make the ventilating appliance serve for the two seams a roadway was cut into the Deep Arley pit in the Two Feet seam, and the Deep Arley winding shaft originally a downcast was made into the upcast for both seams.

Erection of Turbo-Fan.

As the shaft was a very old one, and the surface already well built upon it was difficult to find a suitable site for the erection of the fan and drift. Looking forward to the comparatively short life of the pit it was also deemed inexpedient to put up a large slow running fan, or to go to any unnecessary expense in drift or foundations. After careful consideration the erection of a Parson's turbo fan was decided upon. It was then found possible to make use of a small workman's cabin and smithy for its cover, and to build the drift along the surface of the ground at the banking level. The pit top was framed and boarded with 1½ inch T & G boards, from the banking level to the level of the rod bearers in the head-gear, suitable sliding doors were arranged and the drift was framed and double boarded and was joined into the existing cabin wall. A circular hole was made in the wall of the cabin and a hollow conical iron casting 5 feet long with flanges was fixed in such a manner as to form at its large end by the aid of the brickwork the connection with the wooden drift, the drift being thereby continued into the interior of the building. This casting was 7 ft. 1 in. at the large and 3 ft. 7 in. at the small end. The small end was bolted directly on to the neck of the fan casing. The cabin had been built upon the old dirt heap and for turbine foundations the floor of this cabin was taken out to the depth of 2 feet, and afterwards filled in again with

concrete—the holes for the pipe races, condenser well, Lewis bolts, &c., being left. I have noted the surface arrangements chiefly to show the small cost entailed in surface erections for a fan of this kind.

Three months after the order was placed for the turbo fan the opinion of Messrs. Parsons & Co. was obtained as to the possibility of fixing an electric generator to the plant. It was found possible to do so and accordingly a 50 K.W. generator was ordered. The effect upon the conditions at the pit was to render the old cabin slightly too short for the work.

Description of Plant.

The installation consists of a compound steam turbine of the condensing type direct coupled at one end to a screw fan, 3 ft. 6 in. dia., and at the other end coupled direct to a 2 pole dynamo.

The steam turbine consists of a cast-iron cylinder in which is arranged a revolving shaft. The annular space between the shaft and cylinder is occupied by rows of blades or vanes, the *fixed* or *guide vanes* being secured to the cylinder, and the moving ones to the shaft. Steam, on entering the annular space, is projected in a rotary direction by the first row of guides, and imparts a considerable portion of its energy to the first row of moving vanes. The moving vanes are so shaped and run at such a speed that the steam on leaving them is practically stationary (so far as rotary motion is concerned) and, on meeting the second row of guides it is again given a spin, the energy of which it delivers up to the next row of motive blades. This action is repeated till, on reaching the exhaust end the steam has been expanded right down to condenser pressure. The force necessary to give the steam its high rotational velocity is obtained from the drop in pressure between each pair of turbine rings and the succeeding pair. It is due, I am

told, to this compounding (or placing of many turbines in series) that Messrs. Parsons are able to show such high efficiency at moderate speeds. If the steam had to be expanded at a single step, the speed of revolution necessary for economical working would have to be something like 30,000 to 40,000 revolutions per minute. The end pressure or thrust caused by the pressure of steam on the blades is counterbalanced by an arrangement of dummy pistons at the opposite end of the turbine. These dummies revolve with the shaft and are serated so as to form a practically steam tight joint. They do not touch anything when running.

The fan is eight bladed, of Manganese bronze, and fitted with wrought-iron discharge cone and bend, and revolves at the rate of from 3,000 to 3,500 revolutions per minute. Its estimated duty at the higher speed is 80,000 cubic feet of air at 6 inch water gauge. The makers guaranteed that the steam consumption per Air H. P. should not exceed 40 lbs., but said they anticipated even better results.

The generator is compound wound for 440 to 475 volts, and to generate from 100 to 110 Amps. It was coupled to the turbine by means of a flexible coupling and is mounted on a strong bedplate.

The bearings of the Turbine, Fan, and Generator are automatically lubricated, the oil being circulated by means of a small reciprocating pump, worm-geared from the turbine shaft.

A similar arrangement is adopted for raising the water required for the condenser, the pump in this case being of the reciprocating double-acting type, 11 in. dia., 6 in. stroke, and running at one-fortieth the speed of the turbine. 18,000 gallons of water per hour is thus raised to a height of 34 ft.

The Condenser is of the Ledward Ejector type, and during the trials at no time was the vacuum higher than 20·5 inches.

The steam for the tests was supplied from a Lancashire two-flued boiler, 30 ft. × 8 ft., at a blowing-off pressure of 150 lbs. and under natural draft.

The boiler was fed by a small Worthington Duplex Pump, the steam to drive the same being taken from the same boiler.

Steam was supplied to the turbine through 3 in. wrought-iron pipes, the size of the exhaust to the condenser being 18in.

Testing.

The Fan had been running for eight-and-a-half months previous to the taking of the steam tests.

The arrangements for the tests, which extended over 51½ hours, were as follow :—

The boiler feed water was taken from the condenser discharge, and was run into a large wooden tank erected near the boiler. The boiler feed pump drew from this tank; the tank was fitted with an outside gauge glass to show the height of the water in the tank. A clear mark was made on this glass to indicate the minimum or low water line, and the maximum or high water line was obtained by filling the tank until the water ran over at a definite outlet provided. The tank was accurately measured, and its water capacity between these two levels obtained. It was found to be 354 gallons. After the tank had been filled to the overflow, no water was allowed to flow into it until the definite low water mark was reached, after which the tank was again filled; the feed pump being stopped while the tank was being filled. The exact number and times of filling of this tank were kept, and owing to the steady nature of the

load no difficulty was experienced in keeping the steam pressure and the boiler water level very constant. The firing was always easy and regular. To provide a steady load for the Dynamo, a temporary resistance was arranged. It consisted of a barrel of water, in which was suspended a pair of sheet-iron electrodes, with suitable means for raising and lowering to adjust the load. A supply of cold water was laid on the arrangement to keep it cool.

The air measurements were taken by means of a high speed Biram Anemometer, on which two-minute readings were frequently taken and the results averaged. The water gauge pipe was fixed at right angles to the flow of the air, and 10 feet from the fan. Tests were also made at further distances with the same result.

Fifteen minute interval readings were taken throughout the trials of the other work being accomplished, such as volts, amperes, revolutions, steam pressures, vacuum gauges, &c., and the results, which are recorded in the annexed tables, are taken after careful averaging of these readings.

No. of Trial.	Speed of Turbine, Revs. p. min.	Air.		Electricity.		Horse Power.			Percentage of full guaranteed load.
		Quantity in C. F. per. min.	Water Gauge.	Volts.	Amps.	Air.	Elec.	Total.	
1	3,360	112,000	5·177	478	80·6	91·3	51·6	143	100
2	3,320	109,300	4·95	480	87·0	85·2	56·0	141	99
3	3,200	97,500	6·10	481	85·0	93·7	54·8	148	104
4	3,040	99,000	4·00	..	..	62·0	..	62	44

In Nos. 1 and 2 tests the water gauge was normal, that is, the ordinary conditions of the mine were not altered.

In No. 3 test an artificial obstruction was put in the main return air-way to increase the water gauge.

The No. 4 test was taken for the purpose of estimating the actual loss due to the cutting-out of the Electric load, as is done during the working hours of the day.

The amount of water evaporated for these trials and the steam consumed per useful or effective horse power is as under:—

No. of Trial.	Steam Pressure.		Duration of Trial, hrs.	Water Evaporated Total lbs.	Steam Consumed per hour. lbs.	Steam Consumption per U. H. P. lbs.
	Boiler, lbs.	Cylinder, lbs.				
1	147	122	10¾	49,560	4,610	32·2
2	147½	122	13½	62,260	4,612	32·6
3	147	125	18¾	81,420	4,342	29·2
4	147	80	8½	23,630	2,780	44·5

Owing to the peculiar qualities and construction of the turbine, by which the continuous motion of the rotor or revolving piston displaces the reciprocating piston, resulting in the absence of any definite starting and ending of the stroke—as is obtained in engines of ordinary construction—it is not possible to obtain a diagram showing the amount of work being done in the cylinder.

While the tables that have previously been shown are results taken from actual tests and are thus in one sense the only absolutely reliable figures that can be given, it is nevertheless possible to calculate, taking these figures as a basis, the work that is being done by the steam as it enters the turbine, in other words, by assuming a certain percentage of loss between the brake horse power and the useful horse power, and also between the cylinder horse power (or indicated horse power) and brake horse power, it is possible to arrive at a close approximation to the steam consumption per indicated horse power. This has been arrived at in the following manner.

The horse power in the air and in the electricity has been calculated as shewn from the average of the readings taken.

The efficiency of the fan has been taken as 55%. The brake horse power absorbed by it at this efficiency is therefore $\frac{\text{A. H. P.}}{\cdot 55}$.

The efficiency of the dynamo has been taken as 90%. The brake horse power is thus $\frac{\text{E. H. P.}}{\cdot 90}$.

The total brake horse power of the turbine is thus $\left(\frac{\text{A. H. P.}}{\cdot 55} + \frac{\text{E. H. P.}}{\cdot 9}\right)$.

To arrive at the horse power in the cylinder it is assumed that the loss between it and the brake horse power due to the friction of the engine is equal to that of a high-class reciprocating engine, viz., about 10%.

The cylinder horse power thus becomes $\frac{\text{B. H. P.}}{\cdot 9}$.

This cylinder horse power is afterwards referred to as the indicated horse power.

The steam consumed per indicated horse power has been obtained by dividing this resultant into the steam consumed per hour in the tests.

Further, as the power developed by the steam turbine was utilised partly in moving air and partly in generating electricity, both of which processes involve different efficiencies, the work of correctly apportioning the steam consumed per air horse power or per electric horse power is somewhat complicated, and it becomes necessary to arrive at it through the steam consumed per indicated horse power.

Steam consumed per air horse power equals $\frac{\text{I. H. P. lbs.}}{\cdot 9 \times \cdot 55}$ and

Steam per electric horse power equals $\frac{\text{I. H. P. lbs.}}{\cdot 9 \times \cdot 9}$.

The following table gives the results of these tests. I have also included side by side with them, at the request of Messrs. Parsons & Co., the corresponding steam consumptions corrected for a 27 inch vacuum.

No. of Trial.	Vacuum in inches Hg.	Steam Consumed.					Coal used p. I.H.P. lbs.	Corrected for 27 inch Vacuum Steam Consumed.				
		p. U.H.P. lbs.	p. I.H.P. lbs.	p. B.H.P. lbs.	p. A.H.P. lbs.	p. E.H.P. lbs.		p. U.H.P. lbs.	per I.H.P. lbs.	p. B.H.P. lbs.	p. A.H.P. lbs.	p. E.H.P. lbs.
1	19¼	32·2	18·6	20·7	37·5	23·	2·68	27·4	15·8	17·6	31·9	19·6
2	19½	32·6	19·1	21·2	38·5	23·6	2·96	27·7	16·25	18·0	32·6	20·06
3	19½	29·2	16·95	18·8	34·2	20·9	2·44	24·8	14·4	16·0	29·1	17·8
4	20½	44·5	22·06	24·5	44·5	..	3·17	37·9	18·75	20·85	37·9	..

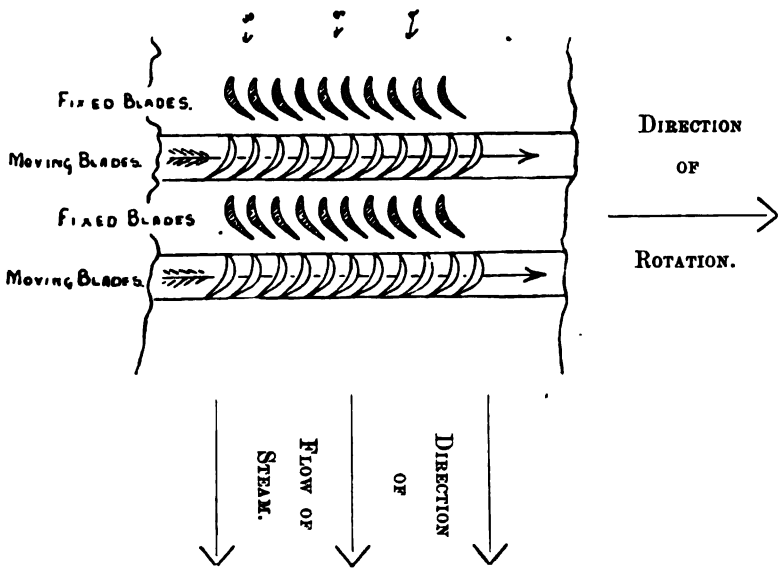
A coal slack test, covering 41 hours, gave the quantity of coal burned as 12 tons 8 cwts. The total quantity of water evaporated during this time was 193,240 lbs. The amount of water evaporated per lb. of coal was thus 6·95 lbs. The feed water temperature was 80° F. There was no economiser or other feed water heater in use. The height of the W.I. chimney was 40 feet.

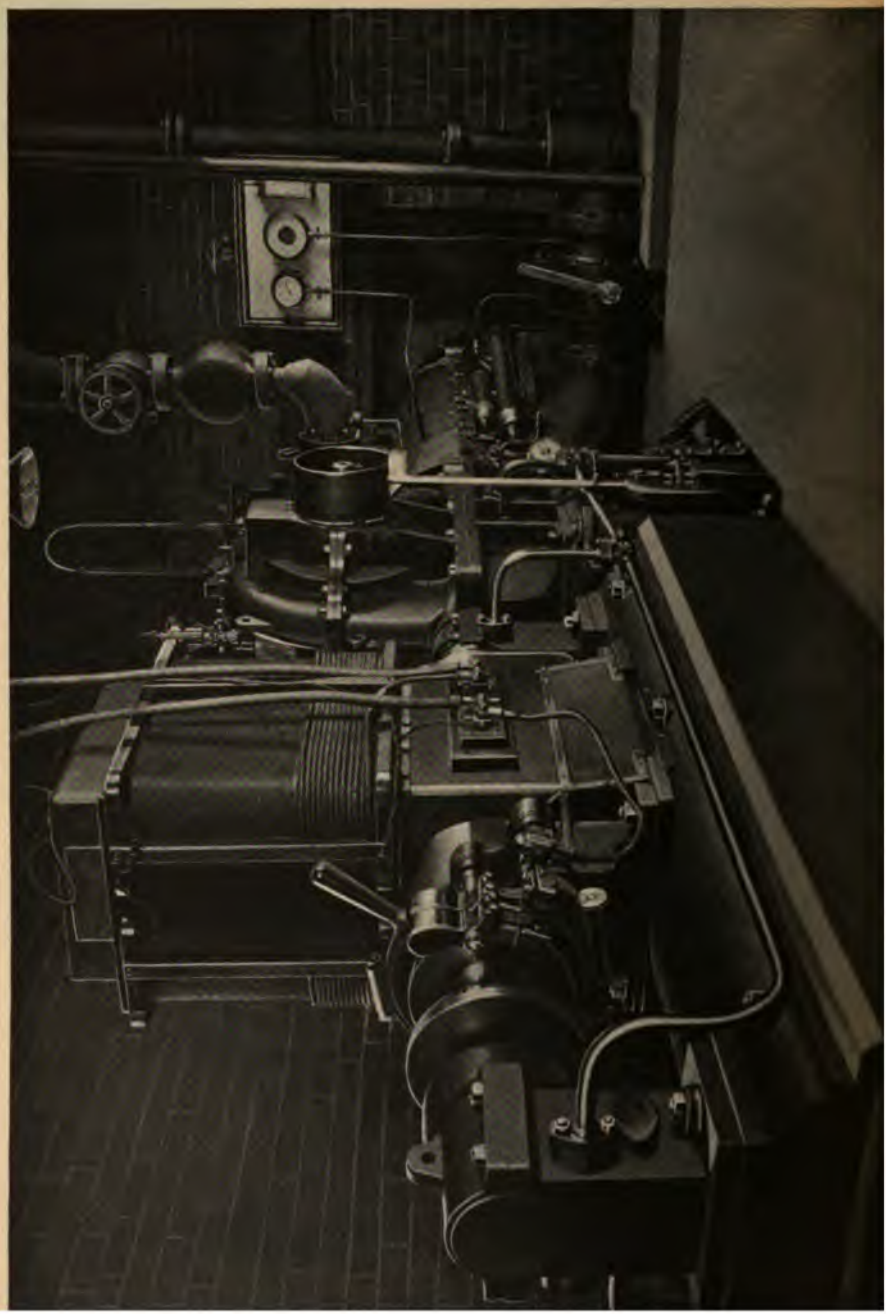
In conclusion I may say, apart from the production of an offensive musical note when it was first erected, which necessitated the building of a brick discharge chamber to cover the W.I. discharge cone, the installation has worked regularly and effectively night and day. The attendance needed is not even of ordinary closeness, one man does the whole of the firing at the boiler, and at intervals inspects the fan. The automatic forced lubrication and the effective governors on the engine combine to render the whole installation so far as our experience has gone as reliable and steady as need be, and such I should say as to compare most favourably with other types of fans.

There are a few points which probably would prove interesting to the members which I respectfully ask to be allowed to show by the aid of the lantern. Before doing so, I should like to make mention of Mr. Brancker, the Managing Director of the Collieries, who, from the first, has

taken great interest in this plant. It is due to his readiness to share in the responsibility, and to his desire for real improvement that this particular form of fan was adopted. I may also say that at my request, and by courtesy of the Secretary, Mr. Carnegie as representing Messrs. Parsons and Co. has consented to be present and will no doubt be very pleased to explain the construction of the turbine or to give his experience at other places. We are indebted to him for much skilful advice in connection with the erection of the turbo plant.

ARRANGEMENT OF TURBINE BLADES.

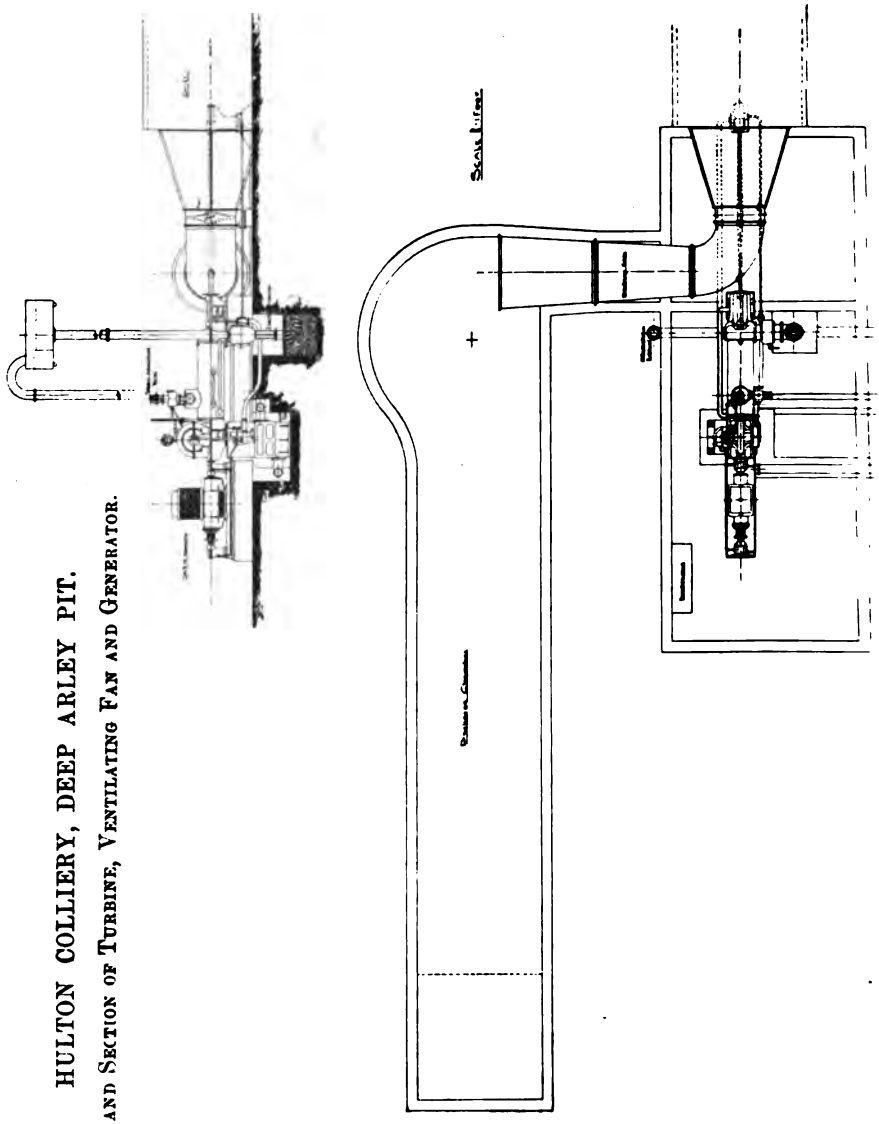




HULTON COLLIERY.—DEEP ARLEY PIT.
VIEW OF TURBINE AND GENERATOR.

HULTON COLLIERY.—DEEP ARLEY PIT.

VIEW OF FAN FROM FAN DRIFT; SHOWING END BEARING AND LUBRICATING PIPES.



HULTON COLLIERY, DEEP ARLEY PIT.

PLAN AND SECTION OF TURBINE, VENTILATING FAN AND GENERATOR.

The CHAIRMAN: This seems to be a modern application of the steam turbine to the ventilation of coal mines. No doubt there are many members in the room who have not seen it in operation, and who will scarcely be able to thoroughly understand it, from the immense number of figures that have been put before them, and the variety of drawings; but there probably are some who have seen the turbine at work who may say something on the subject, and then we will have a vote of thanks to Mr. Tonge for kindly bringing it before the meeting. It is the first time we have had it here.

Mr. R. WINSTANLEY: Have you had any indication of heating owing to the high speed?

Mr. TONGE: Not once.

MR. H. STANLEY ATHERTON: I don't think I am the only person who has had an opportunity of seeing this installation, but some few months ago I had the opportunity of visiting the colliery with Mr. Tonge and seeing the apparatus at work. Everything was proceeding successfully, so far as I could see, and was likely to do so. I travelled along the outlet to see if there was anything special to be noted, and I saw that the men had, when ascending the shaft, to be very careful lest their caps were drawn off their heads by the air current, and passed through the fan into the air drift. So it was evident a pretty good current of air was travelling. In short, the whole of the machine was working in a very satisfactory manner. There was nothing that you could find any fault with as regards what you could see in the ordinary working, and Mr. Tonge expressed himself perfectly satisfied with the results. I have very great pleasure in moving a vote of thanks to Mr. Tonge for bringing the subject forward so that we shall have a record of it.

Mr. ROBINSON: I have much pleasure in seconding the vote of thanks to Mr. Tonge. I also have been to see the turbine at work, and was very much taken with

it. Mr. Tonge deserves our congratulations for having ventured to put down such a novel plant for ventilating purposes. I think it is of great simplicity and worthy to be strongly recommended. I was struck with the working of the fan. It seems to be working in a very efficient manner. If Messrs. Parsons & Company can get over the difficulty as to the noise produced by the escaping air, I think they will have accomplished all that is necessary to recommend it to colliery people. I certainly think something must be done in regard to that, and I understand they have the matter under consideration. They expect to get rid of the noise by increasing the area of the exhaust chimney.

The motion was unanimously adopted.

The CHAIRMAN: So many figures about horse-power make it rather difficult to comprehend. Would you be good enough to tell us, concisely, what is the length and area of airway, the water gauge, the quantity of air, and where the water gauge was placed?

Mr. TONGE: I mention in the paper that the length of the airways averaged about 5,000 yards in one mine, and about 3,000 in the other. The air currents only join together in the shaft. There are two mines, and in each case the air travels right down to the bottom of the brow; then it is split, in one case, into three courses, and the total course of the air is 5,000 yards. In the other case it is split into two courses, and the total course of the air is 3,000 yards. The water gauge was 6 inches in one case, but under normal conditions the water gauge is 4 inches. We are working at 4 inches to-day, and getting something over 90,000 cubic feet of air. To obtain the 6 inch water gauge we placed an obstruction in the airway in order to test the fan. We have taken the water gauge at different places. At present it is fixed 14 feet from the fan. We

have taken it in another part of the drift, and it has shown only a slight difference.

The CHAIRMAN: Can you tell us the temperatures of the upcast and downcast shafts at the time the experiments were made?

Mr. TONGE: I am afraid I could not. I believe I have the temperatures recorded in a book, but it is not here, and I do not remember the figures. In the downcast we formerly had steam, and the shaft was rather warm.

The CHAIRMAN: That would be operating against the turbine.

Mr. TONGE: Slightly against it. If we stopped the turbine the ventilation reversed.

The CHAIRMAN: It is a subject we shall have to adjourn for discussion. The figures you have put before us appear really very satisfactory. The quantity of air, the apparent smallness of the apparatus, and the very high water gauge that is obtained are matters that require consideration before a person can make up his mind thoroughly on the subject. Of course we have had a great many applications of the steam jet in this country. I remember trials of it being made at various collieries, including the Ince Hall Colliery, where the application of it was made on a better plan than at any other place I have seen. But when the steam jet was proposed it was amazing what opposition it had to encounter. People in those days were so wedded to the furnace that they scarcely gave a deliberate hearing to any other proposal. That has all passed away, and we have now at nearly every principal colliery vast ventilating fans instead of the furnace, and the steam jet has disappeared almost entirely except for temporary purposes; but this turbine seems something new and likely to bring about a new era of ventilating power; therefore we must have time to consider what we have heard to-day.

Mr. JAMES TONGE: I have no information to give in addition to what my son has given. There is a saying that "nothing beats old age but youth," and in this case youth has beaten old age, and very much. I must confess I was very anxious about this fan when it was first started. I could scarcely myself advise that it should be tried, but my son went very fully into the matter, in co-operation with the Managing Director, Mr. Brancker, also with Mr. Carnegie and others who seemed to be able to speak as to the fan, and I must say that after eight months' trial I begin to have very great confidence in it. I think it is a fan that will be adopted, gradually, perhaps. It is not everyone that has confidence to try it in a hurry, but I think it is a fan that will be found to do very useful work.

Mr. LIONEL B. WELLS: I am sure we are greatly indebted to Mr. Tonge for the trouble he has taken in preparing the paper, and, as one of the members of the Council, I consider they ought to give him an additional vote of thanks for bringing so many interesting particulars before the Society. It seems to be a question of great interest. It is not one on which I can speak, but I have been very much interested in seeing for the first time one of these turbines to a large scale, and I think we ought to ask Mr. Carnegie to tell us something further in reference to the development of this machine. We should be glad to hear also what it has cost. I am sure it would be of interest to many here to know that, if Mr. Tonge has no objection.

Mr. WINSTANLEY: I shall be glad if Mr. Tonge, or Mr. Carnegie, will state what is the longest time one of these turbines has been at work. I would like to ask Mr. Tonge if I may be permitted to view the plant.

Mr. TONGE: Certainly.

A. Q. CARNEGIE (of C. A. Parsons & Co.) said:—Mr. Chairman, Gentlemen.—I don't think anyone in this

room can have listened to this paper with greater pleasure than I have done. I have been closely associated with Messrs. Parsons & Co. in the development of this type of fan, and have been largely responsible for the design and construction of the fan that Mr. Tonge has so ably described to us. I think Mr. Tonge has placed the Society under a deep obligation to him for having brought before it the results of so exhaustive a series of trials.

Those of you who have had some experience in running prolonged steam consumption trials will be able to appreciate the amount of care that is necessary to make the results reliable, and also the amount of work entailed in tabulating the results into the comprehensive form in which Mr. Tonge has presented them.

Tables of figures always are, at first sight, somewhat bewildering, but I am sure it will be found that these trials will stand comparison with those of other first-class fans in general use at collieries. I would like to add a few remarks to what Mr. Tonge has already said about the lowness of the vacuum during the trials. It never rose higher than 19¼ inches of mercury, and this was due to several causes:—the condenser was of the ejector type, having no air pump, and depending solely upon the high velocity of the combined stream of water and steam for the ejection of any air that might be present in the steam.

This class of condenser was put in, in preference to a surface condenser, on account of its lower initial cost, as the pit was not expected to have a very long life and it was not considered advisable to put down expensive plant in such a case.

Further, the condenser and also the circulating pump were arranged for, before the addition of the dynamo was decided upon, and, as the dynamo absorbs nearly one-third of the power of the turbine, it will be seen that the condenser gear is overloaded to the extent of nearly 50 per cent.

One other feature that went against a good vacuum was that the temperature of the circulating water was nearly 80 degrees Fahr., instead of 60 degrees as specified by the makers, Messrs. Ledward; the cooling power available was therefore only a fraction of what it should have been, considering the amount of steam that had to be condensed.

Had we known at the outset that a dynamo was to be fitted, a motor driven centrifugal pump would doubtless have been used, and it would have been placed near the water lodge at as nearly the water level as possible. This pump could have been speeded up so as to give a greater volume of water, and much better vacua would have been obtained in spite of the smallness of the condenser.

Mr. Tonge gives, at my request, steam consumption figures that have been corrected for a higher vacuum. I have here some figures, which were obtained in some special trials at Heaton works, and which show that the allowance that has been made is not at all an extravagant one. The turbine in this case was driving a 350 Kilowatt electric generator and ran at a speed of 3,300 revolutions per minute.

With 27·7 in. vacuum the steam consumption per K.W. hour was 22·1 lbs.;

With 26·5 in. vacuum it was 23·6 lbs.; and

With 17 in. vacuum it was 27·9 lbs.

You will note that the fall in vacuum to 26·5 in. increased the steam consumption by about 6½ per cent., while the fall to 17 in. gave an increase of 26 per cent. in steam. If these figures are plotted in the form of a curve it will be found that with 19¼ in. vacuum the consumption is 22 per cent. greater than with 27·7 in. It would therefore have been quite reasonable to have reduced the Hulton fan consumption by about 18 per cent., but the correction actually applied was only 15 per cent.

Mr. Tonge has mentioned that the addition of the dynamo

was only decided upon some three months after the original plant was ordered. This meant a demand for 50 per cent. more power from the turbine, and the only modification that was made to meet this, was a slight increase in the turbine blades. I mention this again to show the remarkable flexibility of the steam turbine engine.

Mr. Winstanley asked for particulars as to the longest run that had been made with a turbine fan, and also as to the possible danger of the lubrication failing.

There has been a fan of this type running at Messrs. Cookson's lead works at Howden-on-Tyne for nearly seven years. It has been run day and night (Sundays included) in hot lead fumes, at a temperature of nearly 500 degrees Fahr., and has only been stopped twice a year, at Christmas and at race week, to allow of the flues being cleaned out. Exacting as colliery requirements usually are, I don't think anyone could ask for a more severe test of endurance than this. There have been no repairs or adjustments made to this fan since it was first erected.

Another turbo-fan is at work at Clara Vale Colliery, Wylam-on-Tyne. It was first installed nearly five years ago, and for some time was used for experimental work. For the last two years, however, it has been returned in the Colliery Official Report as the sole ventilator of the pit, and it has twice run the full twelve months without a single stoppage. When stopped last Christmas, every part of the plant was found to be in excellent condition, the bearings not having shown any signs of wear. While on the subject of Clara Pit fan, I may mention that it is housed in a rough wooden shed, the door of which is kept locked and the key kept in the old fan engine house some few minutes walk from the turbine. The men who fire the boilers take this key and give a look at the turbine twice a day, just to make sure that there is plenty of oil in the tank. You will, I am sure,

agree with me that the plant is not overburdened with attention, nor does it require any more than it gets.

The lubrication of all the bearings is automatic and under pressure. Oil is contained in a central tank and from this it is drawn by a reciprocating ram pump and forced, at a pressure of from 3 to 5 lbs. per square inch, through the various bearings. After leaving the bearings it is drained by gravity through large return pipes to the central tank, and so kept in continual circulation. The pump is driven at one-fortieth of the speed of the turbine, the reduction in speed being obtained by means of worm and worm-wheel gearing.

The only thing likely to cause a failure in the oiling is dust, if it should get into the oil in sufficient quantity to cause the pump valves to stick. This is, however, easily prevented by changing the oil say once a week and filtering it through clean cotton waste.

When the fan was first erected, we had some trouble in getting rid of the musical note. It was found that when sufficient resistance was placed in the drift to make the "equivalent orifice," on which the fan was working, equal to that for which it was designed, the note ceased. When the pit was in its normal condition of working the note was a most unpleasant one and varied in pitch with the speed of the fan, just as might be expected from the number of vibrations set up by the fan blades.

Many experiments were made and the cause of the note was clearly ascertained, so that in future installations it can be avoided, but the silencing chamber, described by Mr. Tonge, was found to answer its purpose very well, and as it occupied space formerly covered by the pit refuse heap it has been allowed to remain.

Regarding the life of the turbine engine, you will have seen that the only parts in frictional contact are the bearings.

The blades are just clear of the shaft and cylinder respectively and are therefore not subject to wear in the slightest degree. The steam in a compound turbine has a comparatively low velocity and so far as we can tell, after having had steam turbines in use daily for periods of over 14 years, its velocity is much too low to have any cutting action on the blades. The blades are made of a special alloy of the nature of bronze, and are caulked into grooves one at a time, so that each individual blade can be, and is, carefully examined for flaws before being secured in its place. The blading material is drawn like wire to the required section and its grain is therefore lying in the best direction to ensure the greatest possible strength.

One very important claim that can be made for the turbine engine, and one which is sometimes overlooked, is that no lubrication is required by any of the parts in contact with steam. I have already pointed out that none of the internal parts are in rubbing contact, so that it is quite unnecessary to provide any lubrication for them. The steam after leaving the turbine is perfectly clean and after being condensed it can be returned straight to the boilers, without any of the intermediate filtering that is so necessary where ordinary reciprocating engines are used, and which at the best often allows a considerable quantity of oil to find its way into the boiler, much to the detriment of the boiler and its efficiency.

During the fan trials at Hulton Colliery, it was found necessary to turn the exhaust of the little boiler feed pump into the feed measuring tank, as steam for working it was taken from the same boiler as was working the fan. This little pump was of course fitted with the usual sight-feed lubricator on its steam pipe and oil was thus passed into the feed tank and into the boiler.

After the test had been going on for some little time, Mr. Tonge and I found that the lodge was covered with a

very distinct film of oil for the first time since the fan had been started.

A question was asked by Mr. Wells about the comparative cost of the turbine driven fan as compared with ordinary makes of fans, and I may say that I understand from Mr. Tonge that the cost of this fan was very considerably lower than the other estimates, especially when the cost of buildings and foundations is taken into consideration. I will leave the actual cost figures for Mr. Tonge to deal with, as he has them in more detail than I have.

I don't think, Gentlemen, that I have anything further to say, except to again thank Mr. Tonge for his very able paper and also for his kind references to myself. I would also like to thank you, Mr. Chairman, for allowing me to join in this discussion.

Mr. WELLS: You are working with saturated steam?

Mr. CARNEGIE: Yes.

Mr. WELLS: And with superheated steam you would do better, would you not?

Mr. CARNEGIE: That would make a difference of one per cent. for every ten degrees Fahrenheit of superheat.

Mr. TONGE regretted that he could not give any accurate idea of the cost; he had not separated the items, nor had he taken an account of everything, so would have to speak from memory. He would be glad, nowever, to give any information on any particular point that he could. Mr. Tonge bore cordial testimony to the way in which he had been assisted in this enterprise by his officers, and explained how they dealt with the inlet of air from old workings.

Mr. CARNEGIE further stated, in reply to a question, there was no danger of the fan flying to pieces.

A vote of thanks was passed to Mr. Dickinson for presiding.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XXVII. SESSION 1901-1902.

The ORDINARY MEETING of the Members was held on Tuesday, June 10th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. JONATHAN BARNES, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. WALTER LEA, Collins Green Colliery, Collins Green, near Earlestown.

Mr. THOMAS H. MACHIN, Hyde Lane Colliery, Hyde, Cheshire.

Mr. J. W. HUTCHINSON read the following paper "On Experiments with Duplicate Ventilating Fans at Bamfurlong Colliery."

ON EXPERIMENTS WITH DUPLICATE VENTILATING FANS AT BAMFURLONG COLLIERIES.

By Mr. J. W. Hutchinson.

During the year 1900 it was found necessary to increase the ventilating power at the Bamfurlong Collieries, either by constructing additional furnaces or erecting ventilating machinery. The furnaces already in use needed extensive repairs, and it was decided to erect ventilating machinery. It was first proposed to erect one large fan to ventilate the whole of the mines, but the position of the pits and the nature of the strata near the surface made the undertaking a very costly and also a very unsatisfactory one, as the space at the largest upcast pit was limited, and did not leave sufficient room between the railway lines to erect a fan and engines capable of giving the required ventilation for the whole of the mines. There was sufficient room at the No. 2 upcast pit to have erected a large fan, but the pit was considered to be too small in diameter, especially as it was being used as a winding pit, to pass the quantity of air required. It therefore meant either erecting a fan at each pit or making an underground or overhead drift across the railway lines.

The top strata consists of 4 feet of soil and moss, and immediately below there is 13 yards of quicksand and marl with water, and it was not thought advisable to disturb this owing to the amount of machinery and plant erected. The construction of an overhead drift was considered, but the idea was abandoned.

There are four pits sunk at the collieries. Nos. 1 and 2 pits are sunk to the Pemberton Mines, a depth of 240 yards, and

are used to work and ventilate the Pemberton and Ince mines. No. 1 is used as the downcast and No. 2 the upcast pit; each pit is 12 feet diameter. Nos. 3 and 4 pits are sunk to the Arley Mine at a depth of 640 yards, and are used to work and ventilate the Wigan and Arley Mines; the No. 3 pit is the downcast, and is 15 feet in diameter; No. 4 pit is the upcast, and is 16 feet in diameter.

The mines, previous to the introduction of fans, were ventilated by three furnaces; one furnace being placed at the bottom of the No. 2 pit in the Pemberton 4 ft. Mine, a depth of 240 yards, and produced 70,000 cubic feet of air per minute, at 1·8 inch water gauge at the separation doors. The other two furnaces were placed at the No. 4 pit, one in the Wigan 5 feet Mine, at a depth of 350 yards, and the other in the Wigan 4 feet Mine, at a depth of 380 yards. These two furnaces combined produced 160,000 cubic feet of air per minute at 1·75 water gauge at the separation doors. These air measurements included the fresh air necessary to feed the furnaces, which in the Pemberton Mines was 15,000 cubic feet per minute, and in the Wigan Mines 32,000 cubic feet per minute.

Three second-hand Waddle Fans were purchased; one fan was 35 feet in diameter and the other two were each 30 feet in diameter.

The 35 feet fan was erected at the No. 2 pit, to ventilate the Pemberton and the Ince Mines, and is producing 130,000 cubic feet of air per minute at 2·4 inch water gauge in the drift near the pit top, with 58 revolutions of the engine and fan (the fan being direct driven).

The two 30 feet fans were fixed at the No. 4 pit. Each fan has an inlet of 12 feet diameter. Both fans were driven direct by one high-pressure single horizontal engine, having a cylinder 30 inch diameter, with an ordinary slide valve,

and 54 inch stroke, fixed between them. This engine was a second-hand one, and was used temporarily as an experiment.

A fan was fixed at each side of the engine-house, and a double balanced crank used, adjustable pedestals being fixed on each side of the engine bedplate. The fan shafts were cut short, to bring them as near together as possible on account of the limited space between the railway lines, which was 38 feet. The drift walls are carried from the floor level up to the staging of the pit brow, so as to form a large drift, and also to dispense with the timber supports of the staging. The drift at the pit is 32 feet wide and 19 feet high, and is divided into two smaller drifts, each being 23 feet high, and 5 ft. 6 in. wide at the fan inlet, and fitted with doors, so that the fans may be used separately or together.

On the 5th of January, 1901, measurements of the air, produced by running one fan, were taken underground, one fan being shut off by means of the doors referred to; and also by running both fans. Measurements of the air were also taken with the separation doors open at the pit bottom so as to give the air a free course from the downcast to the upcast pit. Diagrams were taken at the engine with both fans running only. The temporary engine worked very satisfactorily up to 60 strokes per minute, but the piston speed of 540 feet per minute was considered very high for an engine that had to run constantly.

A cylinder of the same diameter as the former one, but having a 36 inch stroke, was substituted and fixed on the old bedplate, in order to run the fans at a higher speed if necessary. This cylinder was fitted with Meyer's cut-off motion working variable expansion gear, and worked very satisfactorily for some months, when, owing to

subsidence of the brick pillar supporting the outer pedestal of one of the fan shafts, heating of the fan shaft bearings took place to such an extent that one fan had to be uncoupled, and the ventilation produced with one fan only, assisted by one of the furnaces. It was then resolved to drive the fans by means of ropes.

There was just sufficient space between the railway lines to build an engine house with the engine pillars close together. This was done, and a bedplate fixed on one of the pillars to receive the cylinder of the engine already driving the fans direct. A driving pulley of 12 feet diameter, having grooves for 11 ropes of $1\frac{1}{2}$ inch diameter, was fixed on the engine shaft, and two 5 feet diameter pulleys, each having grooves for five ropes of $1\frac{1}{2}$ inch diameter were fixed upon the separate fan shafts so that the fans could be run independently of each other. This left a space between the two pulleys of the width of one groove. A bed plate, having pedestals at each side, was fixed for the fan shaft bearings. The engine worked very satisfactorily up to 70 revolutions of the fan per minute, but was not of sufficient power to run at a higher speed with the boiler pressure available, the cut-off could not be used and the ropes had a good deal of swag in them. This was due mostly to the large rope wheel being too light.

Tests were made by Mr. Saint and Mr. Matthews, His Majesty's Inspectors of Mines, on December 7th, 1901, and there were present Mr. Tonge, Sen., and Mr. A. J. Tonge. One fan only had been running for six hours before the tests were made. The air measurements were first taken underground at the usual measuring places, with one fan running 63·6 revolutions per minute at 1·55 inch W.G. After the underground measurements were taken, air measurements were taken in the drift at the same speed.

The same fan was then speeded to 74 revolutions per minute, producing 2-inch water gauge, and air measurements were taken in the drifts; the fan being kept running for 1½ hours at the increased speed before the measurements were taken. Both fans were then started and allowed to run for half an hour at 63·6 revolutions, the water gauge being 1·9 inch, and measurements were again taken in the drifts. Both fans were then increased to 72 revolutions per minute, which produced 2·5 inch water gauge, and measurements again taken in the drifts. Time would not allow measurements to be taken underground with two fans running, and I might point out that when one fan only is running, there is considerable leakage at the door which shuts off the other fan drift, the leakage coming through the fan that is stationary. I estimate the leakage to be 15,000 cubic feet of air per minute, which practically comes direct from the atmosphere, so that the only way to get the true difference between one fan running and both fans running is to take the measurements underground.

Measurements were accordingly taken again on the 9th December, 1901, with both fans running at the same number of revolutions that the single fan had run when His Majesty's Inspectors of Mines took the measurements underground.

In the meantime another engine was being made, similar to the one already in use, in order to provide a pair of coupled engines, and the makers (Messrs. Wood & Gee, of Wigan,) replaced the driving wheel by a much heavier one at the same time that this additional engine was attached. The fans are now being run by a pair of 30-inch horizontal high-pressure engines, with steam cut off at ½ stroke. They are running smoothly and most satisfactorily, and if necessary one fan can be run separately by the one or both engines by

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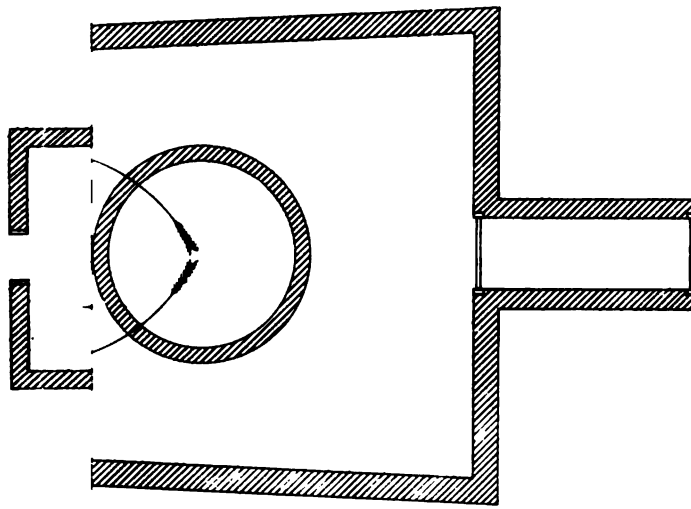
To Illustrate Mr. J. W. Hutchinson's paper.



taking off five of the ropes from the main driving wheel, or both fans can be run by one engine. There is no heating at the bearings of the engine or fans.

Further measurements were taken on June 1st, 1902, with the fans running at different speeds, and diagrams were taken of the engines. Measurements were also taken on June 8th, 1902, underground, with one fan running at the same speeds, and diagrams of the engine were taken. The figures given in the table vary somewhat, but are the actual measurements taken.

When the tests were made in January, 1901, there were several underground steam hauling engines exhausting into the upcast pit, and the exhaust steam or vapour was discharged in large quantities from the fans, so much so that it was impossible to see surrounding objects for several yards from the fans.

Before the tests were made by Mr. Saint and Mr. Matthews this exhaust steam had been reduced at least 70% owing to the steam hauling engines having been removed from the mine and erected at the surface, and band ropes taken down the pits for hauling purposes. There is now no exhaust steam visible at the fan outlets. Changes have also been made underground, some districts have been stopped and others commenced to work, and this has had a tendency to increase the resistance. Driving the fans by means of ropes has considerably reduced the useful effect of the fans as compared with direct driving.

The drawings show the present arrangement of the engines and fans, &c.

The following is a table of the tests and measurements made during the experiments:—

TABLE OF MEASUREMENTS.

Date.	No. of Measurement.	Quantity of Air C.F. per min.	No. of Fans running.	Engine Revs. per min.	Fan Rev. per min.	W.G. at Drift.	W.G. Underground, Arley.	W.G. Underground, Wig. 4ft.	Temp. of Drift (inside).	Temp. outside.	H.P. in the Air, Drift W.G.	H.P. in the Air, Arley Mine W.G.	I.H.P. Engine.	Useful effect, Drift W.G.	Useful effect, Arley Mine W.G.	Where Measured.	Remarks.
1901.									°F.	°F.				Per cent.	Per cent.		
Jan. 5	1	130,000	1	60	60	1·4	..	..	63	37	No	diagram	taken.	..	..	Underground..	Fans direct driven.
,, 5	2	186,805	2	60	60	2	..	..	63	37	58·87	..	92·5	63·64	..	,, ..	,, ,,
,, 5	3	149,900	1	63	63	1·55	..	..	63	37	No	diagram	taken.	..	..	,, ..	,, ,,
,, 5	4	204,000	2	63	63	2·1	..	..	63	37	67·5	..	97	69·5	..	,, ..	,, ,,
,, 5	5	220,400	1	60	60	1·25	..	..	63	37	No	diagram	taken.	..	..	Drift	,, Separation doors open.
,, 5	6	314,955	2	60	60	1·7	..	..	63	37	No	diagram	taken.	..	..	,, ...	,, Underground ,,
Dec. 7*	7	140,542	1	26½	63·6	1·55	..	..	66	53	34·32	..	92·9	36·94	..	Underground..	Fans rope driven, single engine.
,, 7*	8	165,450	1	26½	63·6	1·55	..	..	66	53	40·4	..	92·9	43·48	..	Drift†	,, ,, ,,
,, 7*	9	180 476	1	31	74·4	2·05	..	..	66	53	58·29	..	124·8	46·7	..	,, †	,, ,, ,,
,, 7*	10	199,904	2	26½	63·6	1·9	..	..	66	53	59·85	..	112·9	53·01	..	,, ...	,, ,, ,,
,, 7*	11	218,430	2	30	72	2·5	..	..	66	53	86·04	..	159·2	54·04	..	,, ...	,, ,, ,,
,, 9	12	189,009	2	26½	63·6	1·95	..	..	61	38	No	diagram	taken.	..	..	Underground..	,, ,, ,,
,, 9	13	207,864	2	31	74·4	2·6	..	..	64	38	No	diagram	taken.	..	..	,, ..	,, ,, ,,
1902.																	
June 1	14	184,000	2	26½	63·6	1·9	2·3	1·9	61	64	55·08	66·68	104·7	52·6	63·68	Underground..	Fans rope driven, coupled engines.
,, 1	15	210,000	2	30	72·	2·5	3·2	2·5	61	64	82·72	105·89	158·8	52·09	66·67	,, ..	,, ,, ,,
,, 1	16	235,000	2	35	84	3·5	3·75	3·3	61	64	129·6	138·86	248·7	52·11	55·8	,, ..	,, ,, ,,
,, 1	17	212,000	2	28	66·2	2·2	..	..	61	64	73·49	..	130	56·53	..	Drift	,, ,, ,,
,, 1	18	218,200	2	30	72	2·5	..	..	61	64	85·95	..	158·8	54·12	..	,, ...	,, ,, ,,
,, 1	19	264,610	2	35	84	3·5	..	..	61	64	140·42	..	248·7	56·46	..	,, ...	,, ,, ,,
,, 8	20	163,876	1	30	72	2	2·25	1·9	61	62	51·64	58·1	107·5	48·03	54·04	Underground..	,, ,, ,,
,, 8	21	199,399	1	35	84	2·65	2·8	2·3	61	62	83·23	87·97	171·8	48·44	51·2	,, ..	,, ,, ,,

NOTE.—* Measurements taken by Mr. Saint and Mr. Matthews, H.M. Inspectors of Mines.
† Measurements include leakage from door in drift shut off and passing through stationary fan—estimated at 15,000 C.F. per min.

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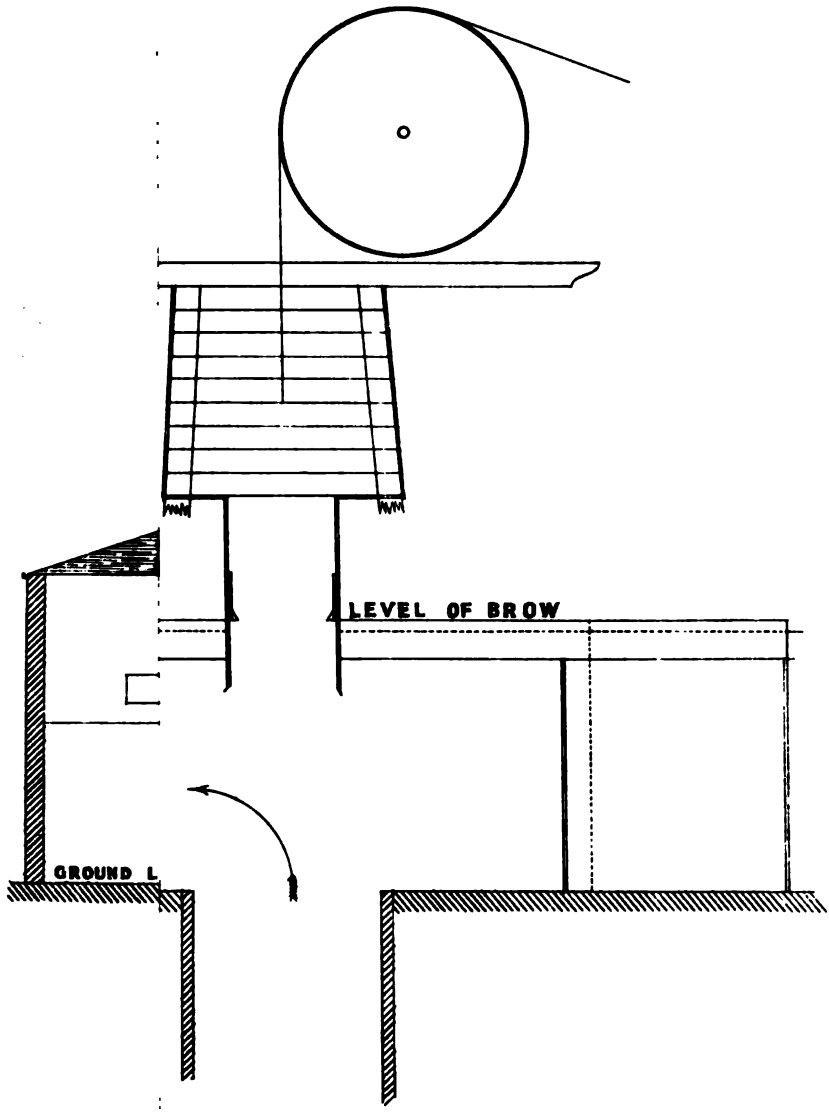
To Illustrate Mr. J. W. Hutchinson's paper.



Mr. JOHN GERRARD: I have pleasure in proposing a vote of thanks to Mr. Hutchinson for coming here to-day and for giving this exceedingly interesting and valuable paper. I am sure it must have taken up a large amount of time. He appears to have gone into the matter most carefully. I am not at all prepared to say anything now in the way of criticism or discussion, but I think we must clear the way by giving him our thanks, and by-and-by we will have, I hope, a very good discussion. Mechanical ventilation is altogether displacing furnace ventilation, and for very good reasons. How anyone can waste a shaft now by using it as a chimney I cannot understand, when, by mechanical ventilation, he can get a larger amount of use from it. There is much that could be said in favour of mechanical ventilation as against furnace ventilation. The consumption of fuel and the necessary repairs of the shaft must, I am quite satisfied from experiments I have seen, make the furnace method the more costly. When Mr. Hutchinson read his paper at Wigan—which, I take it, was preliminary to the one now under consideration—I was interested in knowing what was the additional amount of air that could be got from running two fans of the same size, as compared with one of them. I think he stated that whether you placed the fans as a pair, side by side, or tandem fashion, one before the other, you would not get anything like double the amount of air from two fans that you would get from one. I have heard it stated that under the most favourable conditions you cannot get more than 40 per cent. increase. That is, you may double the fan power, but cannot get double the amount of air through the mine. I can quite appreciate Mr. Hutchinson's desire not to meddle with the surface near the other shaft, considering the character of the strata, for I happened to go there a number of times when the shaft was being sunk, and it was a most difficult operation. Having seen

the strata, knowing something of the quicksand and the amount of water in it, I know how anxious he would be not to meddle with or disturb the other shaft.

Mr. JAMES TONGE, Senr.: I have pleasure in seconding the vote of thanks, and congratulate Mr. Hutchinson on the success of his experiments. It must be a very great convenience and benefit to have two fans in such a position that either one or both can be run; also two engines so that either one or both can be used. In this case, if one fan or one engine breaks down, he is still able to get a fair amount of ventilation with the other.

The resolution was carried.

Mr. HUTCHINSON: I thank you for the vote of thanks. I have been pleased to come and read the paper. I think you will find that the percentage of the useful effect of the fans is about from 53 to 66 per cent., that is by taking the water gauge at the surface and also in the Arley, which is the deepest mine. We get that amount, and, taking all things into consideration, it is all that can be expected.

In reply to questions, Mr. HUTCHINSON said the fans were Waddle's; he could not tell the date of their construction, but he thought they had been built about twelve years. One had been running nine years and the other eight when he bought them. As to the upkeep of the fans, there had been no difficulty at all; in fact they had not cost a penny for repairs since they commenced running.

Mr. GERRARD: Mr. Waddle claims to have greatly improved the construction of his fan, as compared with the earlier ones.

Mr. HUTCHINSON: The bell mouth has been introduced in recently made fans, and it was claimed that by this arrange-

ment the velocity at which the air was discharged into the atmosphere was greatly diminished.

Mr. GERRARD: Yours have not that?

Mr. HUTCHINSON: No. In the old Waddle fan the air is discharged with considerable force, so that you can feel it ten or twelve yards from the fan outlet, but with the bell mouth you will not feel the air more than four or five yards off.

Mr. JOSEPH DICKINSON, F.G.S.: I think some alteration has been made in the Waddle fan since the first was introduced. The fans have now curved blades inside; the first were straight. It is a very fine fan, and very strongly constructed.

Mr. DAVID HOLLINGWORTH: The superiority of fan over furnace ventilation was generally acknowledged, and had been proved at mines with which he had been connected. It was due to the advice of Mr. Waddle, in South Wales, that I first introduced the fans to Staffordshire.

Mr. DICKINSON: Some of the first fans were erected in South Wales.

Mr. DAVID HOLLINGWORTH: Mr. Waddle had great difficulty in introducing them to other parts of the country.

Mr. ALFRED J. TONGE: Mr. Hutchinson has very kindly allowed me to see these fans. It seems to me that the question of duplicate fans is a very important one. There are some of us who have to look forward to the erection of fans, and I think Mr. Hutchinson's experiments will help us, especially when we come to study his paper more closely and to work out the useful effects of the two fans running together as against running them singly. There is a great

difference between what is required in the way of ventilation at a modern pit in its early stages and at a later period. It would be a waste of steam to have too large a fan and engine at the outset. It seems to me that, considering the extra depth of the seams we are approaching, and that the seams are probably thinner, this paper will be extremely valuable in helping us to form an estimate as to whether it would not pay to commence with a small fan, say for ten years or so, and then, instead of taking that one out and putting a larger one in its place—(very often it would be impossible to do that, because one would not be able to stop the working long enough)—we might put a second fan alongside the first, with a corresponding engine also. I am speaking feelingly in this matter, for we have a similar question to decide very shortly at our Hulton collieries, and I am sure Mr. Hutchinson's paper will be very valuable to us from that standpoint.

The following paper was discussed :—

"ON THE NATIONAL INTEREST IN THE FUTURE COAL SUPPLY."

By Mr. William Pickstone.

See Part XIV., Vol. XXVII.

Mr. Pickstone recapitulated the points of his paper and said: The subject is rather outside the objects of the Society, but it is one in which I believe many of our members will be interested. I simply proposed that the nation should take under its control the unascertained coal measures, and as regards the ascertained coal measures that have no present commercial value my proposal is, not that the nation should buy them out, but simply that it should take the control. If it is necessary, buy them on terms of payment that will not be a great tax on the nation. The terms would in that case be that as soon as the coalfields are worked profitably the owner of the land should take a share in the proceeds in the shape of a royalty. Now we know that difficulties arise in the working of an individual coalfield. They arise out of the clashing interests of different ownerships. Some men are cantankerous and difficult to deal with, and refuse to give a coal master a right of way between one royalty and another, because they have a bit of freehold that lies between the two. If the Government, through a mining department of the State, controlled the rights of getting coal independently of the rights of the surface owner, the coal owner would meet with none of those difficulties with which he has now to contend. He would be able to work his coalfield more economically by having fewer shafts, for it would be part of the Government's business to see that no more money

was spent in sinking shafts than was necessary to work a mine out, and we could get a lighter royalty in some cases. At present the royalties are not even, for often you have a poor coal leased at the same royalty as a better coal, and that has led to the poor coal being left unworked, which is a loss to the nation. I want to have the question discussed by this Society, because I want my paper to go before the Royal Commission on Coal Supplies, with the sanction of the Society.

Mr. DICKINSON: I have read Mr. Pickstone's paper. The paper ends with the words that the subject is a large one, and the hope that it will, with the approval of the Manchester Geological Society, go before the Royal Commission now sitting on Coal Supplies. It is to be remembered however that the Society is not responsible for the opinions of individual members, each one having to bear the merits or demerits of his own. Mr. Pickstone is an old and esteemed colliery owner, and as such has known the attendant difficulties of that onerous position. Therefore, whether his paper come before the Commission or otherwise, it is entitled to our respectful consideration. First, let me dispose of his enumeration of the difficulties under which the 1866 Coal Commission laboured in obtaining information. The difficulties had not previously occurred to me as being more than what are found on the average in such undertakings. Many thanks were due to the large body of men, eminent in their respective vocations, who aided by their experience. And as to the quantities of coal unworked, they were computed by persons conversant with the respective coalfields. May the same, if not improved, results attend the present inquiry. His subject under other names has occupied attention here and elsewhere. It was treated upon before this Society by Mr. C. M. Percy, of the Wigan Mining School, and elaborately answered by Mr. Oswald Walmesley, barrister-

at-law. It also only a few years ago occupied the attention of a Royal Commission on Mineral Royalties, one of our past presidents, Mr. John Knowles, of Westwood, Pendlebury, an able colliery owner and mining engineer, being one of the members. Little, if any, change has resulted. That the Government should hold mining property is not new. Many royalties are already held by the Crown. There are the Duchies, Office of Woods and Forests, Lords Commissioners, &c., too numerous for me to particularise, owning minerals in Lancashire, Cumberland, Cornwall, the Forest of Dean in Gloucestershire, the Isle of Man, and underneath the sea, &c. The administration of these has gone through some vicissitudes. In the thirties of last century the mining rights in the Forest of Dean had become so hopelessly intermixed that Commissioners under an Act of Parliament had to adjudicate; this I know, inasmuch as I, then an apprentice under one of the Commissioners, was long occupied on the mining surveys. Greatly improved arrangements resulted, and now not only there but elsewhere the mining is carried out under the advice of able mining engineers. The endeavour to unite properties suitable for large mining operations is good. If effected, suitable areas could be had for expensive deep winnings, and, as stated, the leaving of many needless barriers would be avoided, also objectionable wayleaves, and the cost of pumping water apportioned as already arranged for under the Forest of Dean award. Near where we are now holding our meeting land, at Bradford, Manchester, and elsewhere, has been sold, and the minerals with it, in such numerous small holdings that the minerals are unobtainable. Oddly, on the other hand, in the sister isle, some philanthropists, with an eye only to small farming, are advocating the division of estates into small holdings, carrying with the division, as I know in at least one instance, the division of

the mineral ownership. This, if carried out generally, may seriously interfere with mining operations on a large scale. Some of the other recommended points are perhaps too advanced to meet the views of everybody. Without stipulated rents, or some similar power of control, mineral properties might be taken and locked up unworked, but such control should only be sufficient, and not oppressive. Arrangements for sale at a fair profit have been often tried, but have fallen through. Limiting men's hours of labour might suit those who wish to get it over, but scarcely those who take pleasure in their work. As a youth my hours in busy times were unlimited, and at ordinary times eleven hours a day until 8 p.m., including Saturdays, and after that I attended an evening class. All through my long life they have generally been long hours, and often more than six days a week.

Professor BOYD DAWKINS: I have read this paper by Mr. Pickstone, and certainly feel that it relates to an extremely important question, but I must say that, looking at the condition of things as we find them now, there are very grave difficulties in the way of the Government acquiring such a control as is suggested in this communication. Indeed I do not see how that can be done without interference with the sacred rights of private property, and I doubt whether any Government at the present day would venture to put its hand upon that ark. I fully sympathise with the difficulties which, of course, are presented sometimes by the owners of the surface in the way of working these minerals, but I feel that in all these questions we can only be guided by the light of supply and demand. It seems to me, however we may legislate, we cannot interfere with that commercial law, which is certainly as wide in its range, and as inevitable in its results, as the law of gravitation. There are great practical difficulties in approaching

the question from the point of view suggested by this paper, and I, for my own part, do not think it would be a proper course for this Society to adopt, to formally pledge itself in favour or against the principles which Mr. Pickstone has laid before us in this communication. I do not think that it is our function as a Geological Society. As Mr. Joseph Dickinson has very well remarked, our function is to hear the various views propounded by our individual members, who stand or fall by them, but the Society does not, as a Society, reject or receive, or endorse, any view which is laid before us. I have had pleasure in hearing this paper, and I think it will be useful to have it in print.

Mr. James Tonge, Senr.: As one who took some little part in the last inquiry in ascertaining the quantities of coal, and the depths, and so on, I have been very much interested in this subject for a number of years, and I feel sorry to hear what Professor Dawkins has said, for I rather feel he has hit the mark—that we are not a bit likely to do much in the matter. Still, I think it is a subject of great importance, if only on one point. There is such a vast amount of coal being lost. As Mr. Pickstone has pointed out, there are estates where more coal is being lost around than is to be found beneath them. The loss to the nation is enormous. I am of opinion the Government ought long ago to have had a hand in the working of the coal mines, so as to prevent the loss of that commodity which can never be replaced, and on which our greatness as a nation mostly depends. It has been estimated by eminent mining engineers that in a comparatively short time the best of the coal now being worked will be nearing exhaustion, and then we shall have to buy large quantities from other countries.

Mr. Lionel B. Wells, C.E.: I have read Mr. Pickstone's paper with interest, and listened also to the speeches that

have been delivered. We sympathise with Mr. Pickstone and Mr. Tonge in principle. From what they say it appears that the Government certainly should step in, in some way or another, and deal with the economic working and save from waste the fuel underground. I believe I am right in saying that in no civilised country, except those inhabited by Anglo-Saxons, does the law assign the minerals to the surface owner. All through the Continent of Europe, and in South America, the ownership of the minerals does not follow the ownership of the surface soil, and consequently very great benefits accrue to the nation. The amount of royalty is settled so that all parties are equally dealt with. There is no owner who can hoard his coal, or prevent its coming to the market when it is wanted. Exorbitant royalties are not charged, and difficulties as to wayleaves are more readily adjusted. I think in principle Mr. Pickstone is right, but as to how his ideas can be carried out I am not in a position to say; but it is a principle that we, as Englishmen, should help to establish—that the minerals of the country belong to the nation.

Mr. PICKSTONE: I think I have attained my object. I have got an expression of opinion on the part of members of the Society in this discussion. That was all I was seeking to get—not an expression of approval by the Society, but simply that the discussion should go before the Royal Commission with my paper, whatever the particulars of the discussion should happen to be.

BANN CLAY.

Mr. JOHN GERRARD exhibited a specimen of Bann Clay, obtained from Toome Bridge, by Lough Neagh, County Antrim, Ireland.

Mr. GERRARD said the Bann Clay was found three or four feet thick, and it extended over some hundreds, if not two or three thousand, acres. In appearance it was a dark yellowish clay. On being exposed to the sun the moisture evaporated, and it became extremely light and very fine. Two brothers had leased the area and were exploiting it with considerable financial success. He was told that it cost very little to work the mineral, and that it sold for 25s. a ton on the spot. The leaseholders had put up a small crusher and sieves, and reduced it to the finest impalpable powder, which was used for various purposes—for insulating materials in connection with the electrical business, for covering boilers, for keeping things cool in cold storages, and it was exported to West Africa, where it was used as a daub to keep out the fierce heat. Evidence of leaves was met with in some of the strata.

Mr. JOSEPH DICKINSON: Many years ago Mr. Daniel Devlin, who had a large brickworks at Coalisland, tried to work this clay, but he failed to make anything of it. It is satisfactory now to learn the valuable properties of this mineral.

Mr. GERRARD: It is called Keiselguhr by the producers, I fancy, because it is similar to the clay which bears that name in Germany. It is also called Diatomite or Fossil Meal.

The PRESIDENT: It is not Keiselguhr.

Mr. GERRARD: Mr. Kinahan says it is Bann Clay.

A vote of thanks to Mr. Gerrard was passed.

This concluded the business of the meeting.

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